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MINISTER, HON. H. A. OLSON, MINISTRE • DEPUTY MINISTER, S. B. WILLIAMS, SOUS-MINISTRE

CANADA AGRICULTURE

SUMMER '68 ÉTÉ

COVER PHOTO: Canadian beef production continues at high levels; per capita consumption was 81.6 lb. in 1967, an increase of over 30 lb. since 1950.

PHOTO DE COUVERTURE: La production de la viande de boeuf canadien est en plein essor; la consommation annuelle s'est élevée à 81.6 livres par personne en 1967, soit 30 livres de plus qu'en 1950.

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Contributors, namely, professional personnel in the Department's Research, Economics, Health of Animals, and Production-Marketing Branches, Special Act Administrations (PFRA, etc.), and the Farm Credit Corporation are invited to submit their articles in either English or French.

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Fig. 1—Potato buds are excised from the leaf axils under a low power microscope. Each is then planted in a tube of nutrient solution.

Fig. 1—Bourgeons de pommes de terre excisés des aisselles de feuilles, examinés au microscope de faible puissance. Chacun est ensuite planté dans un tube de solution nutritive.

virus-free potatoes: A REALITY

des pommes de terre sans virus: UNE RÉALITÉ

R. STACE-SMITH AND F. C. MELLOR

Potato growers everywhere will welcome the advent of seed potatoes that are truly virus-free. Virus diseases are a serious problem in crops that are vegetatively propagated. Because a virus invades the entire plant—shoots, roots, and tubers—cuttings from an infected plant will also be infected. Viruses that cause distinct symptoms can be controlled by careful inspection and roguing out of infected plants. But some viruses do not cause obvious symptoms; they merely reduce vigor and yield. It is virtually impossible to rogue out plants infected with these so-called latent viruses, and the virus is propagated with the plant. Such is the case with potatoes; even the best available planting stocks are infected with one or more viruses which are either symptomless or cause only mild foliar marking.

Potato virus X, commonly known as PVX, is one of the latent viruses. It is widespread in potatoes throughout the world, particularly in older varieties. For some varieties, PVX-free stock has been obtained by testing hundreds of tubers until a healthy one was found. But other varieties appear to be universally infected. Netted Gem and White Rose are among the

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R. STACE-SMITH et F. C. MELLOR

Les producteurs de pommes de terre accueilleront avec satisfaction l'apparition de nouveaux plants vraiment exempts de virus. Les maladies à virus causent de sérieux problèmes pour les récoltes à propagation végétative. Du fait que le virus envahit la totalité de la plante, pousses, racines et tubercules, les boutures d'un plant infecté le seront aussi. Les virus qui causent différents symptômes peuvent être enrayés en effectuant une inspection minutieuse et en détruisant les plants infectés. Certains virus ne présentent cependant pas de symptômes apparents mais se bornent à réduire la vigueur et le rendement. Il est pratiquement impossible de se débarrasser des plants infectés par ces virus soi-disant latents et ces derniers se propagent avec la plante. C'est le cas des pommes de terre dont même les meilleurs plants de semence sont infectés par un ou plusieurs virus qui ne présentent pas de symptômes ou laissent seulement de légères traces sur le feuillage.

Le virus X de la pomme de terre connu sous le nom de PVX est un des virus latents, disséminé à travers le monde, particulièrement dans les variétés de pommes de terre les plus anciennes. Pour quelques

Les auteurs sont des phytopatologistes de la Station de recherches du ministère de l'Agriculture du Canada à Vancouver, C.-B.

popular North American varieties of which no healthy tubers have been discovered. PVX has been accepted as an inevitable component of these varieties. In our investigations at the CDA Research Station, Vancouver, B.C., our objective was to develop truly virus-free plants of these two varieties, plants that were free not only from the obviously destructive viruses but also from latent viruses such as PVX. We directed the first step in this program toward the eradication of PVX from Netted Gem by thermotherapy, which simply means heat treatment.

Thermotherapy is based on the established fact that virus multiplication is much reduced, or inhibited altogether, when infected plants are grown at a high temperature. The trick is to select a combination of time and temperature that will inhibit the virus without killing the plant. In some cases the whole plant can be cured by this treatment, but in others the viruses are almost as heat-tolerant as the host plant. If any virus particles survive in any part of the plant after heat treatment, it is only a matter of time until the virus multiplies and re-invades the whole plant. Such a plant eventually becomes as severely affected as it was before treatment. If, however, small cuttings are propagated before the re-invasion occurs, some of the cuttings may be virus-free, and these will develop into virus-free plants. (*continued on page 4*)

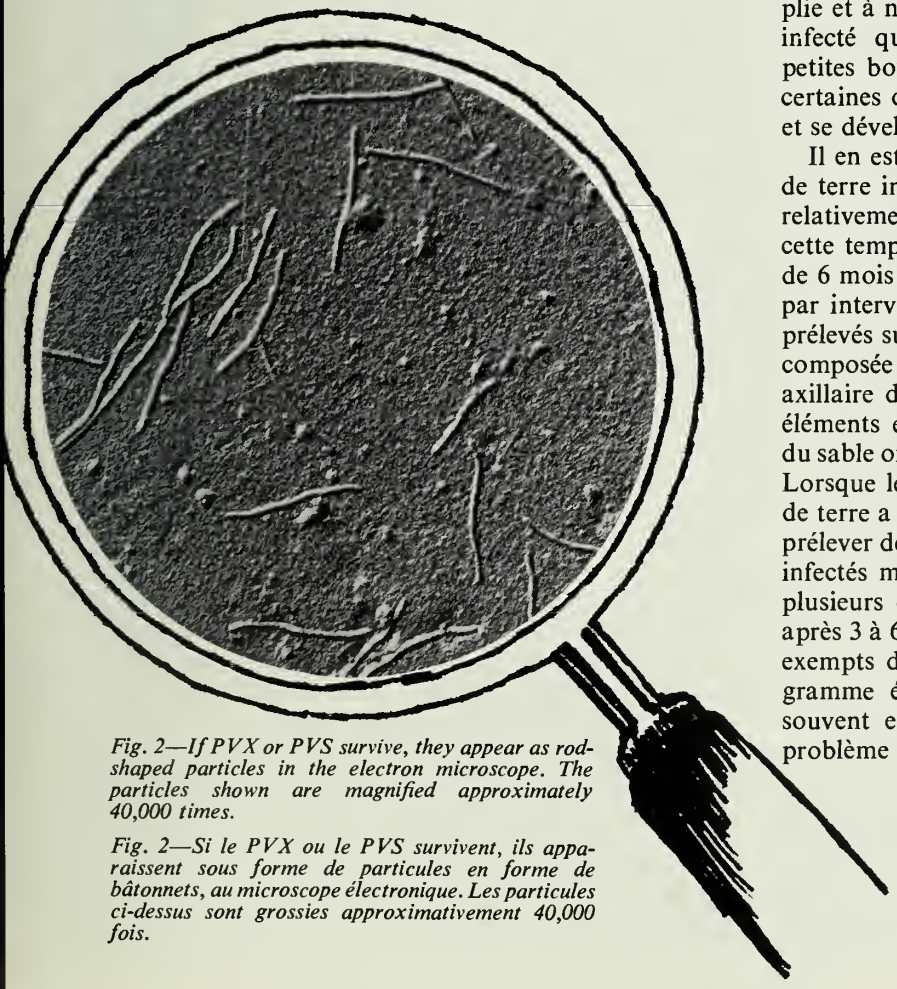

Fig. 2—If PVX or PVS survive, they appear as rod-shaped particles in the electron microscope. The particles shown are magnified approximately 40,000 times.

Fig. 2—Si le PVX ou le PVS survivent, ils apparaissent sous forme de particules en forme de bâtonnets, au microscope électronique. Les particules ci-dessus sont grossies approximativement 40,000 fois.

variétés on a pu obtenir des souches exemptes de virus en examinant des centaines de tubercules avant d'en trouver un sain. D'autres variétés paraissent toutes infectées. La Netted Gem et la White Rose sont dans les variétés d'Amérique du nord celles parmi lesquelles on n'a pas trouvé de tubercules sains. Le virus PVX est reconnu comme un composant inévitable de ces variétés. Au cours de nos travaux à la Station de recherches du ministère de l'Agriculture du Canada à Vancouver, C.-B., notre but était de développer des plants de ces deux variétés complètement exempts de virus, non seulement de virus apparents mais aussi de virus latents tel le PVX. Notre première étape a été d'enrayer le PVX de la Netted Gem par thermothérapie, traitement thérapeutique par la chaleur.

Le principe de la thermothérapie est basé sur le fait que la multiplication des virus est très réduite ou arrêtée lorsque les plants infectés sont cultivés à haute température. L'artifice est de sélectionner une combinaison adéquate temps-température qui détruira le virus sans tuer le plant. Dans certains cas le plant peut être complètement guéri par ce traitement, mais dans d'autres, le virus est presque aussi résistant à la chaleur que le plant-hôte. Si une particule quelconque du virus survit sur une partie du plant après le traitement, en peu de temps le virus se multiplie et à nouveau envahit le plant qui redevient aussi infecté qu'il l'était auparavant. Cependant, si de petites boutures sont utilisées avant la réinfestation, certaines d'entre elles peuvent être exemptes de virus et se développent en plants exempts de virus.

Il en est ainsi avec le PVX. Des plants de pommes de terre infectés ont été cultivés à 95°F, température relativement basse en thermothérapie, mais même à cette température, la durée maximale de survie a été de 6 mois et même moins. Au cours du traitement et par intervalles, de petits bourgeons axillaires ont été prélevés sur les plants traités. La portion coupée était composée d'une petite feuille avec son bourgeon axillaire dormant et une fine section de la tige. Ces éléments étant trop petits pour prendre racine dans du sable ont été greffés sur de jeunes plants de tomates. Lorsque le scion a bien pris, le bourgeon de pomme de terre a grandi produisant une pousse dont on a pu prélever des boutures. Les plants traités sont demeurés infectés même après 6 mois de traitement alors que plusieurs des scions que l'on avait prélevés sur eux après 3 à 6 mois de traitement sont devenus des plants exempts de PVX. Le premier objectif de notre programme était atteint mais comme cela se produit souvent en recherche scientifique, la solution d'un problème entraîne la découverte d'un autre.

(*A suivre page 5*)

Fig. 3—Some of the excised buds produce a shoot and roots after 2-3 months in culture. At this stage, the plantlet is ready for transplanting to soil.

Fig. 3—Certains bourgeons excisés produisent une pousse et des racines au bout de 2 ou 3 mois de culture. A ce stade, la plantule est prête pour la transplantation en sol.

So it was with PVX. Infected potato plants were grown at 95° F., which is relatively low for thermotherapy, but even at this temperature the maximum period of survival was six months, and usually it was less. At intervals during heat treatment, small axillary buds were cut from the treated plants. The portion cut consisted of a small potato leaf with its dormant axillary bud, attached to a thin section of the potato stem. These units were too small to root in sand, so they were propagated by grafting into young tomato seedlings. When the scion became established, the potato bud grew and soon provided a shoot from which cuttings could be taken. The treated plants remained infected even after six months' heat treatment, but many of the scions taken from them after three to six months' treatment developed into PVX-free plants. The first objective in our program had been achieved! But, as often happens in scientific research, solving one problem revealed the presence of another.

There are three methods of detecting symptomless viruses such as PVX: transmission to a sensitive plant which shows symptoms of virus infection; examination of plant sap in the electron microscope, in which the virus particles can be seen; and serological tests. Globe amaranth (*Gomphrena globosa*) is a sensitive indicator plant for PVX. When it is inoculated by rubbing the young leaves with sap from PVX-infected potatoes, distinctive spots appear which indicate the presence of the virus. Many of the scions from the heat-treated potatoes failed to cause these symptoms on globe amaranth. It was apparent, therefore, that these plants were free from PVX. However, when we examined the sap under the electron microscope, long, flexuous rods appeared which were undoubtedly virus particles. Serological tests identified the surviving virus as potato virus S (PVS).

PVS is another latent virus known to be widespread in many potato varieties. Since it survived in all the scions from which PVX was eliminated, it was evidently even more heat tolerant than PVX, and its eradication would require modification of the method that had succeeded with PVX. Since the temperature and treatment period used were both close to the maximum that the potato would endure, the most promising modification seemed to be reduction of the size of tissue unit excised for propagation.

Our attack on PVS was a combination of thermotherapy and nutrient culture of the minute buds from the shoot tips and leaf axils. If the virus concentration in a plant is reduced by thermotherapy, then, in theory, the smaller the portion excised for propagation, the more likely it is to be virus-free. Very small pieces of tissue, with no green leaves for food manufacture, can survive and grow only if they are provided with artificial nutrients.

White Rose and Netted Gem potato plants, infected with PVX and PVS, were subjected to the

(*continued on page 6*)

Il y a 3 méthodes pour détecter les virus sans symptôme tels que le PVX* contaminer un plant sensible qui laisse apparaître les symptômes d'infection par le virus; l'examen de la sève du plant au microscope électronique grâce auquel les particules du virus apparaissent; et les essais sérologiques. Le globe amaranth (*Gomphrena globosa*) est un plant sensible indicateur du PVX. Quand il est inoculé en frottant de jeunes feuilles avec de la sève d'un plant de pomme de terre infecté de PVX, des taches distinctives apparaissent, indiquant la présence du virus. Plusieurs scions originaires des plants traités par thermothérapie n'ont pas manifesté ces symptômes sur le globe amaranth. Il était donc évident que ces scions étaient exempts de PVX. Cependant, lorsque nous avons examiné la sève au microscope électronique, nous avons trouvé des bâtonnets flexueux qui étaient sans aucun doute des particules de virus. Des essais sérologiques ont permi d'identifier ce virus comme le virus S de la pomme de terre (PVS).

Le PVS est un autre virus latent de la pomme de terre connu comme étant disséminé dans plusieurs variétés. Du fait qu'il a survécu sur tous les scions desquels on avait éliminé le PVX, on en a conclu qu'il était plus tolérant à la chaleur que le PVX et que son éradication nécessiterait une modification des méthodes qui avaient réussi avec le PVX. Comme la température et la durée du traitement avaient atteint le maximum suportable pour la pomme de terre, la modification la plus prometteuse semblait être la réduction de la taille de l'élément de tissu exigé pour la propagation.

Nous avons attaqué le PVS en combinant la thermothérapie et la solution nutritive de culture des bourgeons minuscules des bouts de tiges et des aisselles de feuilles. Si la concentration du virus dans un plant est réduite par thermothérapie, alors, en théorie, plus l'élément excisé pour la propagation est petit, plus les chances sont qu'il sera exempt de virus. De très petits éléments de tissu, sans feuilles vertes pour les alimenter, peuvent survivre et grandir seulement s'ils sont approvisionnés de solutions nutritives artificielles.

Des plants de White Rose et de Netted Gem, infectés de PVX et de PVS, ont été soumis au même traitement utilisé pour l'éradication du PVX. Durant le traitement, à intervalles, nous avons excisé le bout de chaque bourgeon axillaire et l'avons planté dans un milieu de culture stérile qui contenait des éléments nutritifs et des substances stimulant la croissance, indispensables pour la survie et éventuellement l'enracinement. L'élément de bourgeon excisé pour la culture était plus petit qu'une tête d'épingle et se composait seulement d'un point de croissance et de 2 ou 3 feuilles rudimentaires. La croissance a été lente dans le milieu de culture artificiel mais après plusieurs semaines, quelques-uns des bourgeons se sont développés en plantules racinées transplantables en sol. *(A suivre page 6)*

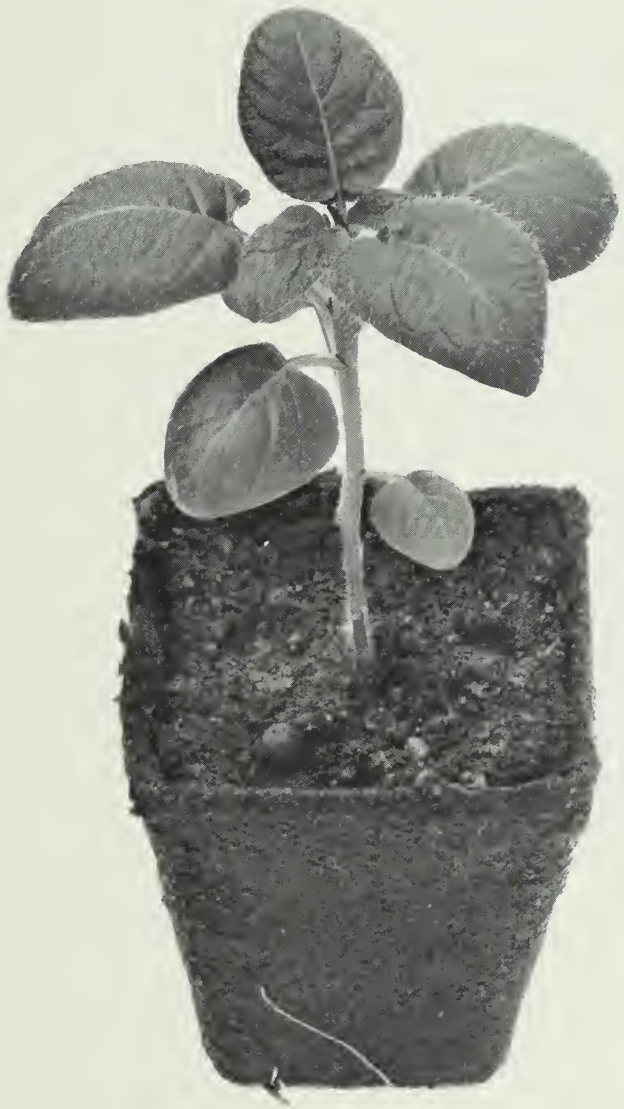

Fig. 4—Three weeks after the plantlet is moved to soil, it is growing vigorously, and ready for testing for virus eradication.

Fig. 4—Trois semaines après la transplantation de la plantule en sol, poussant vigoureusement, elle est prête pour l'essai d'exemption de virus.

same treatment that had eradicated PVX. At intervals during treatment, we dissected out the tip from each axillary bud and planted it in a sterile culture medium which contained the nutrients and growth-promoting substances necessary for survival and eventual rooting. The piece of the bud excised for culture was much smaller than the head of a pin and consisted only of the growing point and two or three rudimentary leaves. Growth on the culture medium was slow but, after several weeks, a few of the buds developed into rooted plantlets which could then be transplanted to soil.

The plantlets were indexed for both PVX and PVS. Again PVS proved to be more heat stable than PVX, but in a few cases both viruses were eradicated. Some of the plants in which neither PVX nor PVS could be detected were selected for propagation. These have been indexed repeatedly, using indicator plants, serology, and electron microscopy. All evidence indicates that they are now free from known viruses.

Our success with Netted Gem and White Rose prompted attempts to develop virus-free clones of other commercial varieties grown in Canada. We now have virus-free plants of the varieties: Canus, Cariboo, Early Epicure, Early Rose, Fundy, Green Mountain, Irish Cobbler, Kennebec, Netted Gem, Norgold Russet, Norland, Pontiac, Warba, and White Rose. Other varieties are still undergoing treatment.

Since both PVX and PVS are easily transmitted from diseased to healthy plants merely by contact, the virus-free plants are being multiplied with great care. If virus-free stock were planted near infected stock, reinfection would occur during routine cultural operations. Initial increase is made in the greenhouses of the CDA Vancouver Research Station. Here, tip-cuttings are taken from a virus-free plant early in the spring. Within a few weeks, each rooted cutting is large enough to provide a few more cuttings. Furthermore, the parent plant, stimulated by removal of the shoot tips, puts out side shoots which provide a second, and larger, crop of cuttings. By continuing this successive propagation, a single virus-free plant will produce more than 2,000 rooted cuttings by planting time.

The first field increase is in an isolated valley, on the farm of a selected grower with many years experience as a grower of Foundation Seed. The plants are grown with special care to avoid any possible contamination from infected potatoes. The first virus-free varieties to reach the field were Netted Gem and White Rose. Virus-free tubers of these varieties will be available to selected growers by 1969. Virus-free tubers of other varieties should be on the market by 1970. Thus we record the beginning of virus-free seed potato production in Canada. ●

Les plantules ont été indexées pour le PVX et le PVS. Une fois de plus le PVS a été prouvé plus résistant à la chaleur que le PVX, mais dans quelques cas les 2 virus ont été enrayés. Quelques-uns des plants exempts de PVX et de PVS ont été sélectionnés pour la reproduction et indexés à plusieurs reprises en utilisant des plants indicateurs, la sérologie et le microscope électronique. De toute évidence, il apparaît qu'ils sont maintenant exempts de virus connus.

Nos succès avec la Netted Gem et la White Rose ont encouragé le développement de clones exempts de virus pour les autres variétés cultivées au Canada. Nous avons maintenant des plants exempts de virus appartenant aux variétés suivantes: Comus, Cariboo, Early Epicure, Early Rose, Fundy, Montagne verte, Irish Cobbler, Kennebec, Netted Gem, Norgold, Russet, Norland, Pontiac, Warba, et White Rose. D'autres variétés sont actuellement soumises au traitement.

Du fait que le PVX et le PVS sont facilement transmis des plants infectés aux plants sains par simple contact, les plants exempts de virus sont reproduits avec beaucoup de soins. Si les souches exemptes de virus étaient plantées près de souches infectées, la réinfection se reproduirait au cours des opérations culturales routinières. Un accroissement initial est entrepris dans les serres de la Station de recherches du ministère de l'Agriculture du Canada à Vancouver. Là des boutures en provenance des extrémités de tiges sont prélevées sur des plants exempts de virus au début du printemps. Au bout de quelques semaines chaque bouture racinée est assez grande pour donner plusieurs boutures. De plus, le plant parent stimulé par le prélèvement des bouts de pousses, produit de nouvelles pousses qui donnent une seconde et plus abondante récolte de boutures. En continuant ces reproductions successives, un seul plant exempt de virus peut produire plus de 2,000 boutures racinées par plantation.

Le premier champ de développement est situé dans une vallée isolée, sur la ferme d'un cultivateur sélectionné pour ses nombreuses années d'expérience comme producteur de plants de pommes de terre Fondation. Les plants sont cultivés avec beaucoup de précautions pour éviter toute contamination possible par des pommes de terre infectées. Les premières variétés exemptes de virus utilisées dans ce champ furent la Netted Gem et la White Rose. Des tubercules de ces variétés exempts de virus seront disponibles pour les producteurs sélectionnés en 1969. D'autres variétés de tubercules exempts de virus devraient être sur le marché en 1970. Nous enregistrons ainsi le début d'une production de plants de pommes de terre exempts de virus au Canada. ●

Fig. 1—Female alfalfa leaf-cutter bee with a leaf cutting tucked beneath her body.

THE ALFALFA LEAF-CUTTER BEE IN SASKATCHEWAN

H. A. McMAHON

The culture and propagation of the alfalfa leaf-cutter bee, *Megachile rotundata* Fabricius, has been under study in Saskatchewan for the past five years. The author, along with D. Cook and D. Heinrich of the CDA Research Stations at Melfort and Swift Current, respectively, and E. Bland of the Saskatchewan Department of Agriculture, has measured the reproductive potential and pollinating efficiency of this imported bee under Saskatchewan conditions.

Unlike honey bees, the alfalfa leaf-cutter bee is known to be an effective pollinator of alfalfa where the climate and environment are suitable. In Saskatchewan, however, its reproduction and pollinating efficiency have varied greatly as to years, districts, operators and even between fields under the same operator. Despite these variations, we can make some general comparison between the Prairie Region and the Northern Agricultural Areas (Parkland Region) of the province. For the period 1964–1966, the reproductivity of the alfalfa leaf-cutter bee in the Northern Agricultural Area varied from 1.06-fold increase at Nipawin in 1964 to 5.0-fold at Tisdale in 1965. In the Prairie Region at Saskatoon, reproductivity has varied from 2.0- to 3.6-fold.

A measure of the pollinating efficiency of *M. rotundata* is the number of cocoons required to produce a pound of alfalfa seed. In the Northern Agricultural Area, 20 to 109 cocoons were required whereas in the Prairie Region about half as much, 11 to 53 cocoons were required.

The pollinating efficiency of *M. rotundata* has been disappointing, particularly in view of its reproductivity. Seed yields have been much less than expected on the basis of number of florets tripped. Seed pods and seeds have been consistently smaller than with alfalfa pollinated by native species.

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Effect of weather. The activity of *M. rotundata* appears to be influenced as much by light as by temperature. If the sky is even moderately overcast, negligible foraging occurs. Even on bright sunny days there is negligible foraging until temperature rises above 65°F, though occasional females forage at slightly lower temperatures. Activity increases rapidly as temperature rises above 70°F, and reaches maximum at about 80°F but even in the greenhouse with temperatures maintained at 80°F or higher, activity ceases if dense clouds obscure sunlight.

The short effective seed-setting season of central Saskatchewan also handicaps this bee as a pollinator of alfalfa. In Northern Agricultural Areas, alfalfa bloom seldom becomes abundant before July 1 and in most years very few flowers, pollinated after August 7, produce mature seed. In the Prairie Region, bloom usually becomes abundant a few days earlier and fall frosts are a little later; the effective seed-setting season may be up to a week longer in the southwestern portion of the province.

Also, temperatures are slightly higher, and usually become high enough for bee activity a little earlier in the day. Furthermore, southwestern Saskatchewan is favored by more sunshine than the Northern Agricultural Area.

An important obstacle to the profitable use of these bees for alfalfa pollination in non-irrigated areas of the Prairies may be the low moisture content of lighter soils, which in some years does not produce enough seed to make the use of *M. rotundata* profitable.

Management. The most critical aspect of *M. rotundata* management in Saskatchewan is that of timing incubation to ensure adult emergence at the best time. The short seed-setting season makes it desirable to have bees in the field as early as is practical. But their emergence before sufficient bloom is usually disastrous; the bees drift away or starve, and in several instances operators have lost entire stocks of bees. In one instance when emerging bees were set out in a field with sparse bloom, the females moved to a nearby sweet clover field for food, and continued to forage the clover after alfalfa bloom became abundant. Analysis of pollen from cells from various nesting sites in the alfalfa field revealed percentages of sweet clover pollen ranging from 23.5 at a location 150 yards from the clover to 96.8 in one about 35 yards from it.

The timely removal of brood from the field is also an important factor in management. In 1964, prewinter mortality ranged from about 17 to 38 percent with bees that were brought in from the field before September 1, and from 41 to 98 percent with bees removed in late September and October.

Management may be further complicated by the need to cope with competitive bloom such as weeds in the alfalfa field, and the control of native parasites and diseases. ●

evapotranspiration measurements

W. L. PELTON AND H. C. KORVEN

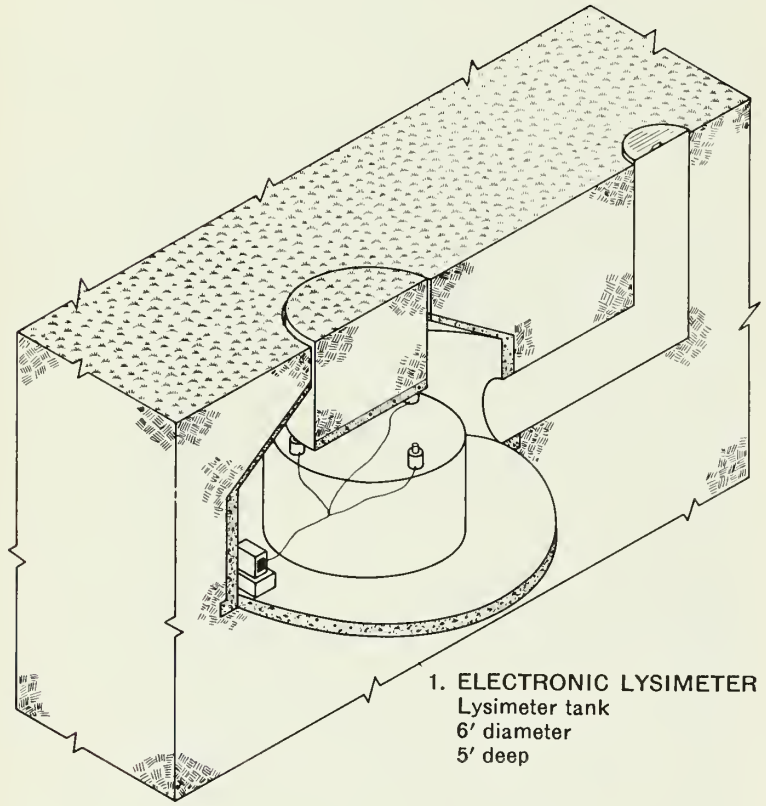
Evapotranspiration (ET) is the process by which water moves from the earth's land surface to the atmosphere in vapor form. ET includes evaporation from the surface of the soil and plants as well as transpiration of water by leaves. A thorough knowledge of evapotranspiration rates is basic to the understanding of soil-plant-water relationships and is a major requirement in the scheduling of irrigation.

To further our knowledge, we have installed, at the CDA Research Station at Swift Current two lysimeter weighing systems suitable for measuring evapotranspiration—one hydraulic and one electronic as shown in the illustrations.

The importance of evapotranspiration has led to numerous proposals of methods and instruments for measuring or estimating the rate and quantity of water used by plants. Many of the methods or instruments have certain limitations. Direct measurements of the changes in moisture content of the natural soil profile are too laborious and time-consuming for practical application; energy budget and vapor transfer methods for calculating ET are too complicated; empirical estimates of evapotranspiration based upon the measurement of one or two meteorological variables (such as temperature, radiation or evaporation), although useful on a local scale, have not been widely accepted.

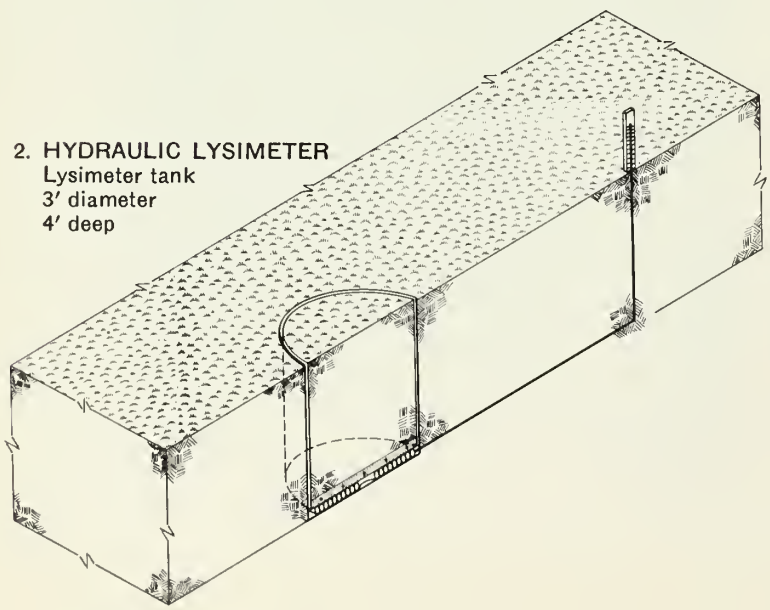
The best method of determining ET for test purposes is to measure the changes in moisture content of a confined soil sample. Lysimeters have been used to study soil water balance problems for many years. A lysimeter is a confined block of soil, which is representative of the surrounding environment, and from which gains and losses of moisture and nutrients can be determined readily. But it is only during the last decade, that lysimetric methods have progressed to the stage where sufficient precision has been attained to warrant their use for evapotranspiration measurements for short periods of one day or less.

Plants respond to daily, and even hourly variations in environmental conditions fostered by changes in radiant energy, temperature, moisture, wind, and other climatic variables. In order to fully evaluate the physiological responses of plants to their environment, (evapotranspiration), these responses must be measured as they occur. The use of various weighing techniques has made it possible to measure ET accurately on a daily, or even hourly basis.



1. ELECTRONIC LYSIMETER
Lysimeter tank
6′ diameter
5′ deep

LYSIMETERS MEASURE RATE AND QUANTITY OF WATER USED BY PLANTS



2. HYDRAULIC LYSIMETER
Lysimeter tank
3′ diameter
4′ deep

Dr. Pelton is a specialist in soil physics and agrometeorology and Mr. Korven specializes in irrigation at the CDA Research Station, Swift Current, Sask.

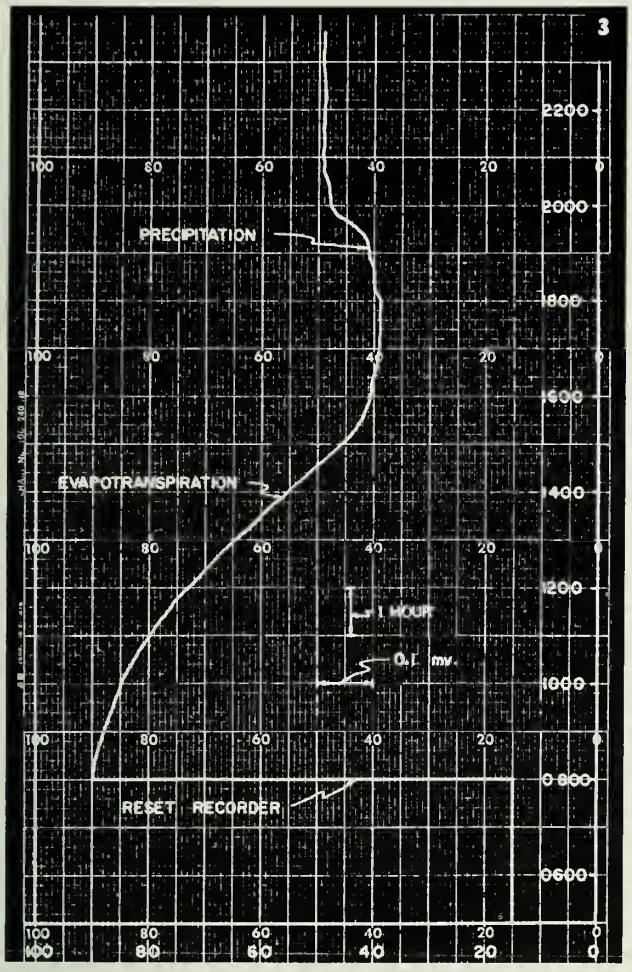


Fig. 1—Cutaway view of a lysimeter which can be weighed electronically and for which an automatic record is produced

Fig. 2—Cutaway view of a lysimeter which can be weighed hydraulically by measuring the height of water in the standpipe

Fig. 3—Evapotranspiration from alfalfa as measured by a hydraulic type lysimeter and plotted on a daily basis. Reduced rates of evapotranspiration are evident for several days immediately following the cutting of hay on June 28 and August 5

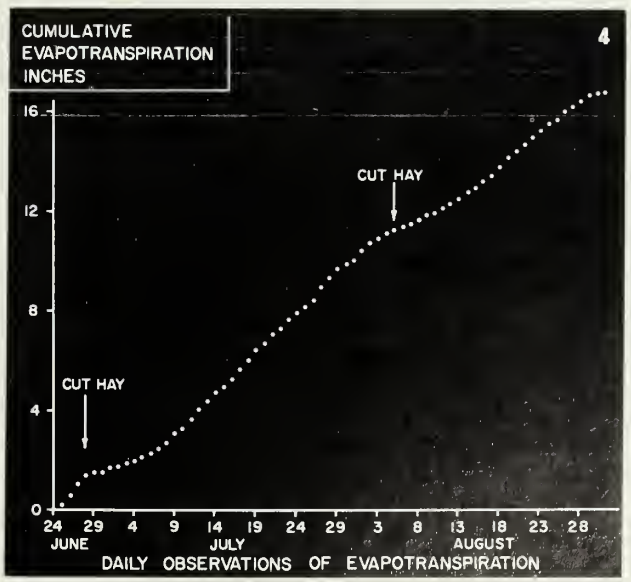
Fig. 4—Chart record showing the loss in weight (ET) of an electronic type lysimeter during the period 8:00 a.m. to 5:30 p.m. and an increase in weight (precipitation) between 6:00 p.m. and 9:00 p.m. 0.1 millivolt is approximately equal to 0.1 in. of water

LYSIMETER INSTALLATIONS

The hydraulic system installed at the Swift Current Research Station utilizes a 2-inch Butyl rubber tube which is coiled under the lysimeter tank, filled with water, and connected to a manometer or standpipe. The water-filled tube supports a tank of soil, three feet in diameter and four feet deep, which weighs approximately 1.5 tons. Changes in weight (resulting from gains or losses of water from the tank through precipitation or evapotranspiration) cause corresponding changes in the water level of the standpipe. Such changes can be read to the nearest millimeter. Observations provide daily measurements of evapotranspiration.

With the electronic weighing system, the lysimeter tank is six feet in diameter, five feet deep, and weighs 7.5 tons; it is supported by three strain gauge load cells. The voltage output of load cells varies with changes in the weight of the supported tank and is recorded automatically on a chart. The system is capable of hourly observations in which weight changes of 1.5 lb (equivalent to 0.1 mm of water) can be detected.

In our studies at Swift Current in 1967, we found that evapotranspiration from irrigated alfalfa varied from 0 to 12 mm per day, and total water use during the growing season was approximately 50 centimeters. Our research revealed that evapotranspiration rates were highest during mid-day when solar radiation was most intense and water use often exceeded 1 mm per hour. We plan to use these data to test various empirical methods of estimating evapotranspiration. ●



CLIMATIC

C. E. OUELLET

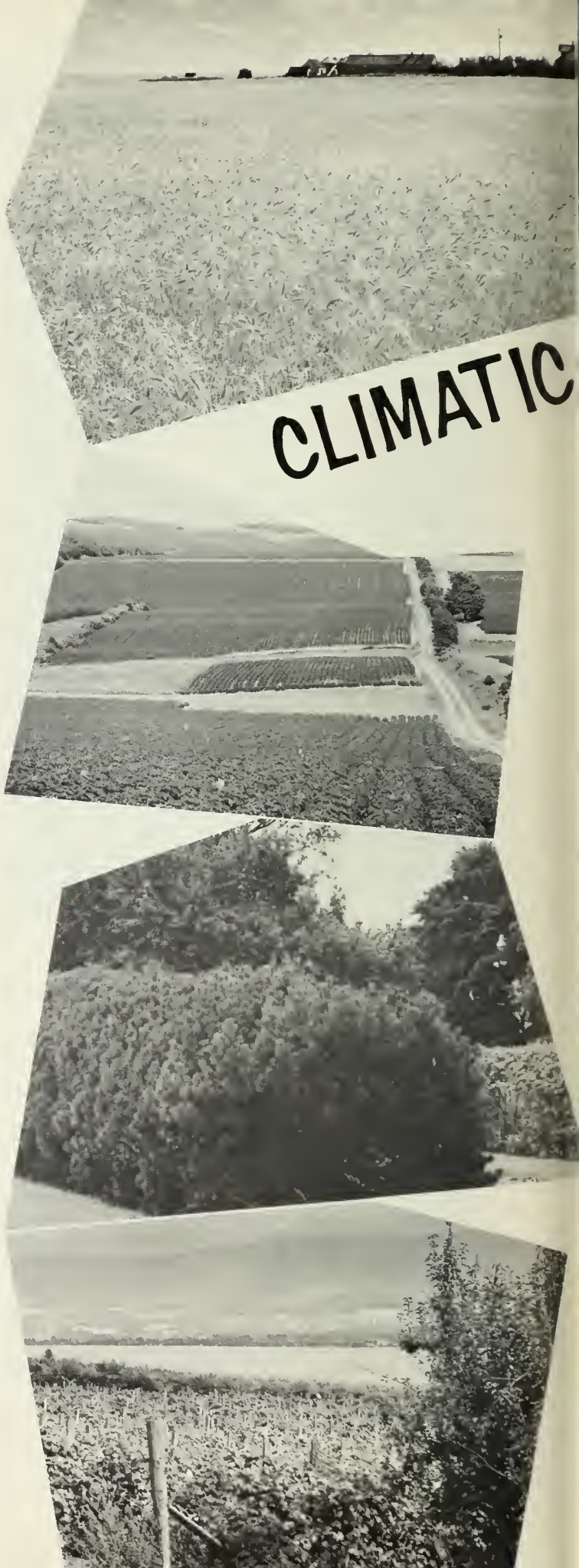
Climatic plant zonation is a way to inform the farmer of the relative value of a region or a site for a particular crop. This consists of determining and mapping the zones within a territory in respect to their climatic suitability for a crop, or some crop characteristics. Normally, climatic zonation should precede soil zonation, because larger areas are affected by a similar climatic pattern than by a similar type of soil. On account of the influence of weather on soil characteristics, climatic zones may constitute a good indicator of the general type of soil and facilitate further zonation of soils within the climatic zones.

We have found that with the present trends in Canadian agriculture it is imperative that zonation maps be prepared for at least the most important crops. This will undoubtedly contribute to a rational planning of crops in regions across Canada. Recognizing this need, several zonation studies are in progress at the Agrometerological Section, Plant Research Institute, Ottawa. One of them concerns the winter survival of 100 perennial forage crops and winter cereals currently grown throughout Canada and portions of the northern United States.

The whole behaviour of a crop or a group of similar crops within an area may be considered in climatic plant zonation. The ultmate goal, then, is an estimate of potential productivity and its variability within each zone. A territory may also be zoned for some characteristics affecting crop yield and quality, such as the time of planting, blooming, cutting (particularly in case of forage crops), and the potential winter survival of a perennial plant.

For practical purposes, climatic elements influencing plants during the year may be summarized over periods of perennial plant life cycle: growing, hardening and wintering. During the growing period, the most important elements are: soil and air temperatures, late frosts in spring and early ones in fall, length of frost-free period, rain, evapotranspiration, soil moisture, light intensity and duration, wind speed and air humidity. Hardening of perennial crops in the fall is affected mostly by range and level of day and night temperatures, hours of bright sunshine, day length, rain and soil moisture. Winter survival of perennial crops is chiefly limited by low temperatures in winter, early fall and late spring frost, winter freezing and thawing, depth and duration of snow cover. However, climatic elements are so much interrelated that they cannot be studied separately. For instance, factors which control development of cold hardiness in fall can only bring out full hardiness if plants have reached the proper stage of maturity, which in itself partly depends on the weather of the previous summer.

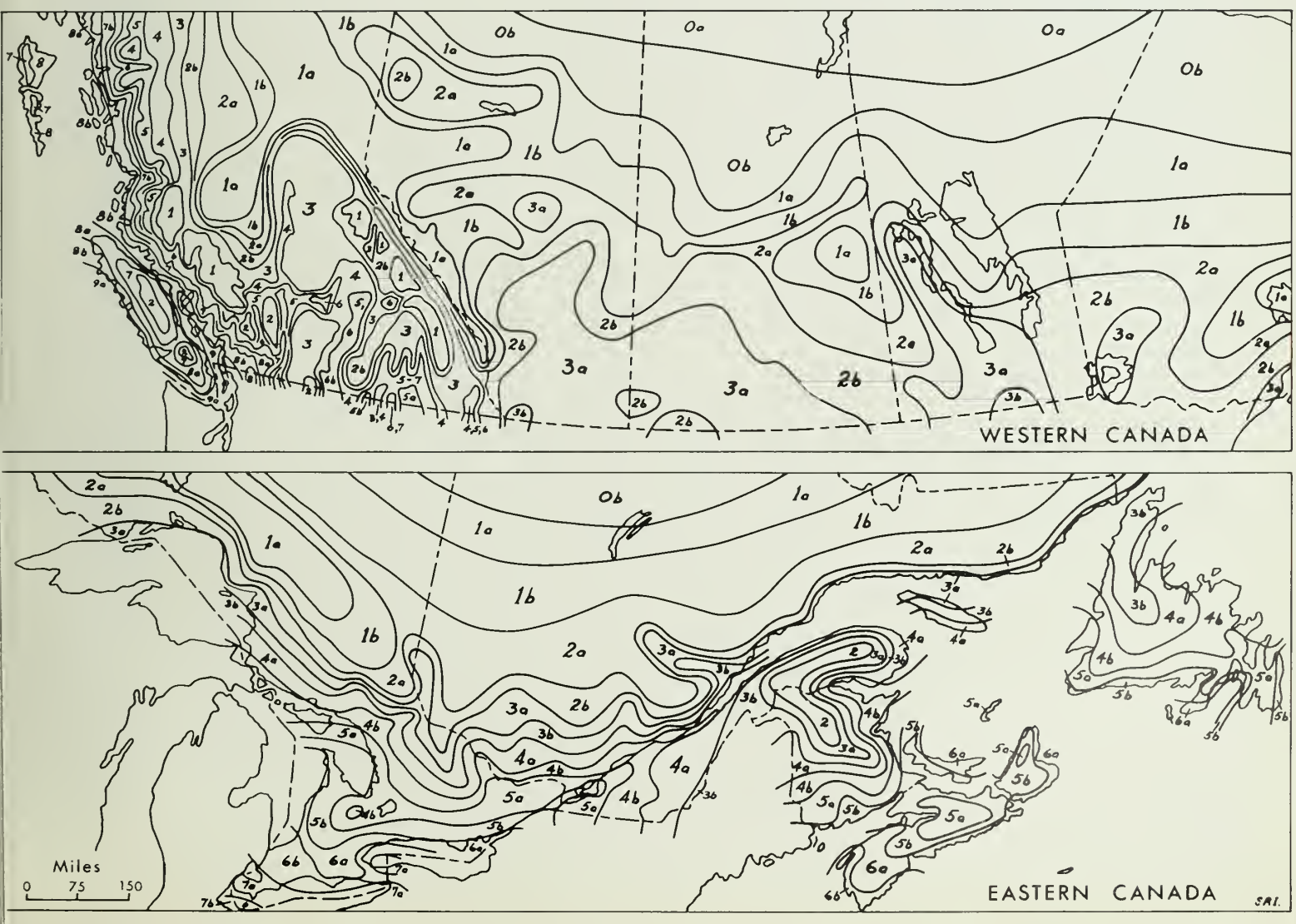
The author is a specialist in ecoclimatology at the CDA Plant Research Institute, Ottawa, Ont.



PLANT ZONATION

Canada is a large country covering several climatic zones. The range of climate which affects crop survival and production is well illustrated by the variation of the frost-free period observed at some 640 sites across the country. A study of the length of the frost-free period by province indicates that half of the sites in the Atlantic Provinces have a frost-free period ranging between 109 and 142 days. The frost-free period is less than 109 days at one quarter of the sites and greater than 142 days at the remaining quarter. In Québec, half of the sites have a frost-free period ranging from 97 to 127 days; in Ontario, from 95 to 146 days; in the three Prairie Provinces, from 82 to 105 days; in British Columbia from 97 to 198 days; in the Yukon and the Northwest Territories from 21 to 60 days; and for the whole country from 90 to 136 days. Such variations which are similar for other climatic elements emphasize the importance of zonation in farming operations where probable yield and profit should be estimated for a specific crop in a particular region. *(continued on page 12)*

Fig. 1—An example of a climatic zonation map



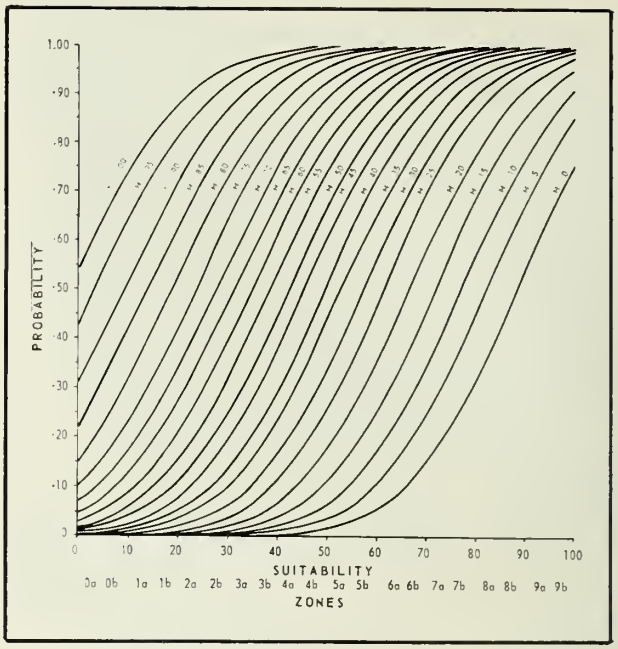


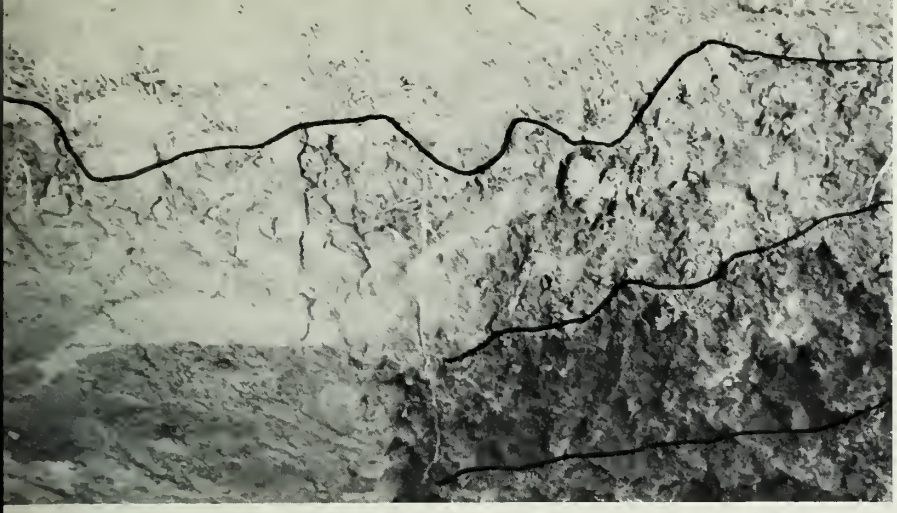
Fig. 2—Probability of winter survival of ornamental trees and shrubs in Canada based on plant hardiness and zone suitability

It is rather surprising that so few crop zonation maps have been produced so far. Two reasons may explain this fact: shortage of phenological and meteorological data and the complexity of crop response to physical environment. At present, phenological data are obtained through the cooperation of Canadian scientists, but the species and varieties tested differ from station to station and observations are not always carried out for the same years and according to the same criteria. Thus, an overall analysis of the collected data is complicated. A network of phenological sites preferably close to existing climatological stations would improve quality and uniformity of plant observations, thereby facilitating zonation studies greatly. As to meteorological data, temperature and precipitation records are available for a number of years and stations, in the more densely populated areas, but fewer stations observe climatic elements such as evaporation, sunshine or wind. Many more new observation stations are required in the fringe agricultural areas where virgin agricultural land has potential use.

Suitability of sites for a crop or a group of similar crops can be estimated by a mathematical model (equation) relating crop survival, growth or yield to one or more climatic elements. Development of such a model is based on phenological and meteorological data collected at a number of observing stations. Since long-term temperature and precipitation records are available for more than 600 stations in Canada, it is possible to estimate suitability indices for these sites and to draw zonation maps from these indices. Three or four climatic elements are usually sufficient to express most of the differences in site suitability for a crop. Because most climatic elements are somehow related to each other, there is no advantage in using more than 6 or 7 variables in the development of mathematical models.

An example of a climatic zonation map is the new "Map of plant hardiness zones in Canada", (Fig. 1) which may be obtained free from the Information Division, Canada Department of Agriculture, Ottawa. This map was based on 8325 hardiness observations for 174 species and varieties of woody ornamentals at 108 observing sites. Suitability indices, as related to the winter survival of these plants, were estimated for 640 stations by means of a model involving seven climatic elements. The map was prepared from indices covering inhabited parts of Canada and includes ten zones (0 to 9) each with two sub-zones, A and B. A list of indicator trees and shrubs with the lowest zone in which they can survive is printed on the margin of the map.

To take full advantage of a zonation map, it should be possible to determine within each zone the probability of yield, survival or any characteristic to which the map is related. Probability of survival of ornamental trees and shrubs in various zones of the hardiness map are based on site suitability and plant hardiness (Fig. 2). In using these curves, it is necessary to have hardiness indices of the species concerned. Indices for 174 species were published by Ouellet and Sherk in Canadian Journal of Plant Science, Vol. 47 (p. 231–238), in 1967. A probability of survival, for instance .80, in a zone for a given species means that the species will survive in 80 percent of the cases. For example if the hardiness index of a species is 60, curves of Fig. 2 indicate that survival probability of this species will be 1.00 in zones 9 and 8, it will vary from .40 to .63 in zone 3 and from .03 to .08 in zone 0. Thus, such a species will almost certainly survive in zones 9 and 8. In zone 3, it may sometimes survive without protection but very often it will require some natural or artificial protection to survive. In zone 0, it will almost certainly winterkill. A good practice will be to plant species with a probability of survival of .80 or more in zones concerned. Then, unless the microclimate is much more severe than the normal for a zone, chances of survival are high. ●



DEEP PLOWING SOLONETZIC SOILS

R. R. CAIRNS

There are over 7,000,000 acres of Solonetzic soils in Alberta[1] and additional large areas in the rest of Canada. These are problem soils that have caused varying degrees of economic distress. The economic problems caused by the soil condition have ranged from complete collapse in much of central Alberta to severe difficulty in other areas. The condition restricts irrigation development in much of western Canada, for the soils are often found in otherwise irrigable areas. For example, the William Pearce Irrigation Project, which was proposed for central Alberta, has been rejected because of the presence of areas of Solonetzic soils within the irrigable area—about 230,000 acres being Solonetzic of the potentially irrigable 375,000 acres.

Solonetzic soils developed under the influence of salts. Over the years, rainfall washed the salt and fine clay out of the top few inches, but not out of the top few feet. The fine clay deposited in a B horizon just under the layer of topsoil. Thus, the soils now have a fairly mellow, but unproductive topsoil layer, varying from less than one inch to about six inches in depth, over a very hard, dense layer, which also varies in depth and is underlain by a salt accumulation layer.

In general, deep tillage as commonly practiced, has had little effect on crop yields at Vegreville. In our experiments we have tried 14-inch deep plowing, 22-inch deep chiselling, 12-inch deep chisel cultivating, deep cultivating with Beavertail points and many other practices. We discovered that none of these methods improved yields and any that elevated the B horizon (sometimes called hard-pan) were detrimental. On the other hand, we found through good management and the use of fertilizers that very acceptable crops could be produced on Duagh silt loam (the common Solonetz soil around Vegreville) and several other Solonetzic soil types without deep plowing, but, on some, such as Kavanagh loam, it has been impossible to produce adequate crops even with good management. Consequently, in the fall of 1966, we established plowing experiments on several Solonetzic soil types, including Kavanagh loam, and very promising responses were obtained on the Kavanagh and certain of the other soils in the 1967 cereal crops.

Deep plowing (22 inches or more) had a distinct beneficial effect on some Solonetzic soils such as Kavanagh loam at Vegreville. Several areas of Solonetzic soils were so plowed in 1959. From 1959 to 1965, cereal crops were grown on these areas and plowing gave small, but consistent yield increases. In 1965 the areas were seeded to brome and alfalfa. There was a dramatic effect of the plowing on the hay crop in 1966. In spite of the severe drought, the plowed areas produced 2000 pounds of hay per acre in the first cut, as compared with only 1000 pounds of hay per acre where the land had not been plowed. The average depth of penetration of the main alfalfa rooting system was 12 inches in the unplowed soil, as compared with 30 inches in the plowed soils.

Study of the soil, six years after plowing, indicated that it had changed greatly. The surface soil was mellower and the salts had almost completely disappeared from the top five feet of the plowed soil. The soluble phosphorus content of the top foot of plowed soil was double that found in the unplowed. The calcium content was increased, the magnesium reduced, and most important, the water acceptance rate was doubled in the plowed soil, as compared with the unplowed soil.

The rejection of the proposed central Alberta William Pearce Irrigation Project because of the presence of Solonetzic soils within the irrigable area points up the challenge of these soils in that they restrict irrigation. The CDA Solonetzic Soil Substation at Vegreville, Alta., since 1959 has been studying the effects of deep plowing on Solonetzic soils and has reported beneficial results such as with cereal crops and with hay crops from brome and alfalfa. We hope that in our continuing research program at Vegreville, study of the effect of deep plowing on the irrigability of Solonetzic soils will unearth new information. ●

[1]Refer to *CANADA AGRICULTURE, Summer '66.*

Dr. Cairns is Officer in Charge, CDA Solonetzic Soil Substation, Vegreville, Alta. His last article, "Increased Grain Yields on Solonetz Soil," appeared in *CANADA AGRICULTURE, Summer '66.*

BIOMAGNETISM
A MYSTERIOUS PLANT GROWTH FACTOR

U. J. PITTMAN

The mystery of plant growth has stirred man's imagination since the early days of alchemy. For years he has recognized that heat, light. water and plant foods play a role in producing a plant. Today, man is beginning to recognize yet another factor that affects plant growth—magnetism.

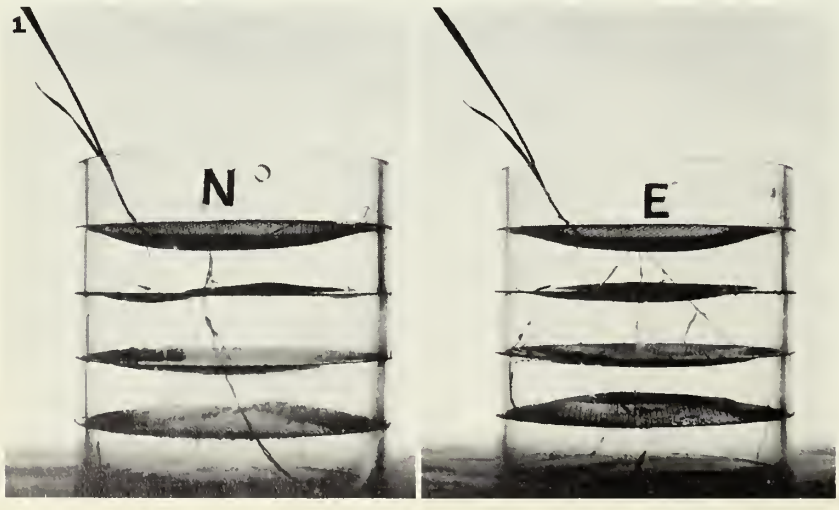
At the CDA Research Station at Lethbridge, Alberta, we have found that magnetism can affect plants in many ways.

Magnetism is that unseen force in the earth that compels a compass needle to point in a northerly direction. It also compels or guides the roots of certain plants to grow in a north-south direction. From observations made across North America we have found that roots of winter wheats, wild oats, some spring wheats and some weed species generally align themselves in a north-south plane approximately parallel to the horizontal force of the earth's magnetic field. In western Canada this plane of root growth is oriented slightly to the east of true north and in eastern Canada slightly to the west of true north because of the position of the north magnetic pole in relation to the true north pole. (The roots of these same plants can be induced to grow in other directions by subjecting them to artificial or introduced magnetic fields of large permanent or electro magnets.)

We have found that winter wheat seeded in rows running at right angles to magnetic north often outyields, by 3 to 4 bushels per acre, that seeded in other directions. Plants growing in rows oriented to magnetic north will utilize soil moisture and plant foods from the inter-row areas more extensively than those in rows running parallel to the geomagnetic field. By using radio-tracer techniques, we have also found that winter wheat plants absorb more phosphorus from fertilizer placed on the north or the south side of the plant than from that placed on the east or west side of it.

The author is an agronomist in the soil science section at the CDA Research Station, Lethbridge, Alberta.

Fig. 1—The roots of wild oats grow in a north-south direction. Left cage: north-south view of root growth; right cage: east-west view of same roots.



Not all roots are influenced by magnetism. Roots of barley, corn, sunflowers, rape, and salsify are not visibly affected by the magnetic field of the earth.

Magnetism also affects the speed of germination of some seeds, depending on how they are placed with respect to the north magnetic pole. We have found that wheat, oats, barley, flax and rye all germinate faster and grow faster during their seedling stages when their seeds are placed with their long axes along a north-south line with their embryo ends pointed toward the north magnetic pole than when they are pointed in other directions. Bean and corn seeds show a similar growth response, but it is not yet known whether all seeds or even all varieties of those tested react identically to magnetism.

Probably one of the most interesting biomagnetic responses known in plants is that exhibited by dormant seeds that have been "magnetically treated". Our tests show that many seeds, if exposed to a magnetic field for a definite period before planting, will germinate more uniformly and grow faster than seeds not so exposed. Wheat seeds that have been held between the poles of permanent magnets for 240 hours (10 days) prior to planting germinate faster and grow more during their seedling stage than control seeds. Growth of corn and bean seeds that have been exposed to a magnetic field with their embryo ends or micropylar ends toward the north pole of the magnet for 10 days prior to planting is usually 2 to 3 times greater than that of unexposed seeds during the first 3 days. In field tests we have found that green snap beans grown from magnetically treated seeds that are planted with the micropylar end toward the geomagnetic north pole mature more uniformly and yield more than those grown from untreated seeds planted randomly. There is some evidence that sweet corn may behave similarly.

The mechanism of biomagnetic responses in plants is still unknown. We hope that continued research will help to explain this fascinating phenomenon of plant growth. •

Fig. 2—Flax seeds grow more in 48 hours when their embryos are pointed to the magnetic north pole than when pointed west.

Fig. 3—Corn seeds magnetically treated for 240 hours before germination grow faster than seeds not so treated.

S. J. CHAGNON RETIRES

S. J. Chagnon, associate deputy minister of the Canada Department of Agriculture and vice-chairman of the Agricultural Stabilization Board, retired recently after 24 years of federal service.

He also served as Chairman of the Editorial Board of the Departmental Quarterly, Research for Farmers, *since its inception in 1956, and was appointed Chairman Emeritus of the same board when "CANADA AGRICULTURE—Journal of the Canada Department of Agriculture" superseded* Research for Farmers *in 1966.*

M. S. J. CHAGNON PREND SA RETRAITE

M. S. J. Chagnon, sous-ministre associé et vice-président de l'Office de la stabilisation des prix agricoles prenait récemment sa retraite après 24 ans de service au ministère de l'Agriculture du Canada.

Monsieur Chagnon fut aussi président du Comité de rédaction de la revue trimestrielle Research for Farmers *dès sa fondation en 1956 et devenait président honoraire de ce Comité lorsqu'en 1966,* Research for farmers *était remplacé par CANADA AGRICULTURE—Journal du ministère de l'Agriculture du Canada.*

ECHO

NOTES AND COMMENTS FROM THE FIEL

FCC LOANS AND FARM EXPANSIONS—Farmers continued to demand capital to adjust and expand their farm operations during the 1967-68 fiscal year.

A total of 11,954 loans amounting to $263,236,500 was approved in that period by the Farm Credit Corporation. This compares with 12,167 loans for $247,947,500 in the previous year. It was a decrease of 2% in the number and an increase of 6% in the amount of loans.

Geographical distribution of loans (previous year's in brackets) was:

	LOANS		AMOUNTS	
B.C.	519	(582)	$13,617,400	($15,017,800);
Alta.	2,829	(2,844)	$65,556,200	($62,408,800);
Sask.	3,665	(3,656)	$80,618,600	($72,046,700);
Man.	1,211	(1,122)	$27,933,300	($22,160,200);
Ont.	2,012	(2,042)	$43,956,600	($43,332,600);
Que.	1,406	(1,522)	$25,668,800	($25,941,200);
Atl. Prov.	312	(399)	$ 5,885,600	($ 7,040,200).

Long term credit on favorable repayment terms for the right purposes is essential for the continued growth and development of the agricultural industry.

Significantly, about 75% of the Corporation's new funds were used last year to buy new farm units, acquire additional land or to pay off land debts.

The Corporation also lends to groups or "syndicates" of three or more farmers who have entered into an agreement to share in the purchase and use of farm machinery in order to reduce their costs.

From the inception of lending under this program in January 1965 to the end of March this year, 364 loans have been made to 289 syndicates comprising 1,115 farmers. The total amount loaned was $2,960,833.

There are more than 200 Credit advisors for the Corporation in agricultural centers across Canada.—GEORGE OWEN, CHAIRMAN, FARM CREDIT CORPORATION, OTTAWA.

EXPANSION DES FERMES PAR LE CRÉDIT—Les cultivateurs ont continué à demander des capitaux pour équilibrer ou agrandir leurs entreprises durant l'exercice 1967-1968:

En tout, on a approuvé 11,954 prêts s'élevant à $263,236,500 durant cette période comparativement à 12,167 prêts formant un montant global de $247,947,500 l'année précédente, soit une diminution de 2 p. 100 du nombre, et une hausse de 6 p. 100, de la somme des prêts.

Géographiquement, les prêts se répartissent comme suit (les chiffres correspondants de l'année précédente figurant entre parenthèses):

	PRÊTS		MONTANTS	
C-B.	519	(582)	$13,617,400	($15,017,800);
Alb.	2,829	(2,844)	$65,556,200	($62,408,800);
Sask.	3,665	(3,656)	$80,618,600	($72.046,700);
Man.	1,211	(1,122)	$27,933,300	($22,160,200);
Ont.	2,012	(2.042)	$43,956,600	($43,332,600);
Qué.	1,406	(1,522)	$25,668,800	($25,941,200);
Prov. de l'Atl.	312	(399)	$ 5,885,600	($ 7,040,200).

Les fonctionnaires de la Société du crédit agricole soulignent que le crédit agricole à long terme, avec conditions favorables de remboursement et utilisé pour des fins convenables, est essentiel pour assurer la croissance soutenue de l'industrie agricole.

Il y a lieu de noter qu'environ 75 p. 100 des nouveaux fonds prêtés par la Société, l'an dernier, ont servi à acheter de nouvelles entreprises, en agrandir ou acquitter de vieille dettes sur les fonds de terre.

La Société prête aussi à des groupes ou syndicats de trois cultivateurs ou plus qui se sont entendus pour partager les frais d'achat et d'utilisation de machines agricoles afin de réduire leurs frais de production.

Depuis le début de ce genre de prêts, soit de janvier 1965 jusqu'à la fin de mars cette année, 364 prêts ont été consentis à 289 syndicats comprenant 1,115 cultivateurs. Le montant global des prêts s'est élevé à $2,960,833. Les prêts ont été consentis pour l'achat d'une grande variété de machines qui sont utilisées avec avantage selon la formule coopérative.

La Société a placé plus de 200 conseillers de crédit dans les centres agricoles partout au Canada pour rendre ses services plus accessibles aux cultivateurs.—GEORGE OWEN, PRÉSIDENT, LA SOCIÉTÉ DU CRÉDIT AGRICOLE.

NEW OATS FOR PEACE RIVER—Two new oat varieties, Grizzly and Fraser, licensed last year, are suitable for the Peace River region of Alberta and British Columbia.

Grizzly was developed at the University of Alberta. Compared with Victory, one of the highest yielding oats in the area, it matures in the same time, is more shatter-resistant, and has plumper kernels with a higher hull percentage. In tests in the area, it has yielded 4% more than Victory. Like Victory, however, Grizzly is susceptible to rusts and smuts.

Fraser was developed by the CDA Research Station, Agassiz, B.C. It has Victory's range of maturity, shorter and stronger straw, plump kernels with a lower hull percentage, and good shattering resistance. Yields have been about 2% more than those of Victory for the past five years. Fraser is resistant to smuts and has fair rust resistance.—A. G. KUSCH, BEAVERLODGE, ALTA.

FERTILIZING PICKLING CUCUMBERS—The importance of making sure that crops of pickling cucumbers get enough phosphorus has been shown by 3 years of field tests at the CDA Research Station, Kentville, N.S.

Although nitrogen and potash are needed, phosphorus is the key to an optimum yield from this crop.

Experiments have indicated that nitrogen at 50 lb. per acre, phosphorus at 150 to 200 lb., and potash at 25 to 50 lb. should be adequate for top yields. This means that a fertilizer with a 1-3-1 ratio generally would be satisfactory. Actual rate of application may be varied depending on the fertility status of a particular soil.—E. W. CHIPMAN AND R. F. BISHOP, KENTVILLE N.S.

VEGETABLE DRAINAGE—A special covered ditch drainage system that will conserve soil and increase drainage is being recommended for peat soils in Newfoundland by the CDA Research Station, St. John's West, Nfld.

This spaces drainage ditches 25 ft. apart, leaving no open ditches to hinder field operations and more soil for planting.

To begin, dig each ditch 12 in. wide and 32 in. deep, using a special disc attached to the province's ditching equipment. Then put 20 in. one-by-threes across the ditch at 5 ft. intervals. Place them 8 in. from the bottom of the ditch and twist them so the wide part will hold the scaffold firm.

Cover these scaffolds with slab wood from local saw mills. Then use a tractor-powered rotary cultivator to fill this over with soil, partially straddling the ditch up one side and down the other.

Lime the soil at 3 tons per acre, then cross-cultivate the field to fill the ditches.

Ridging is recommended for the plants, and placing of rows on an angle with the ditches. The result is rows of crops running diagonally across the field, taking full advantage of the drainage from the covered ditches which are draining water downhill.

The planting ridges are necessary to assure vegetable crop production under Newfoundland conditions.

There has been considerable success with vegetables grown on land with ditches placed at 50-ft. intervals, each ditch 2 ft. deep, but extra drainage is needed to support machinery in wet years. Ditches at 75-ft. intervals have been used without adverse effects for water tolerant forage crops because the sod helps support the machinery.—A. F. RAYMENT, ST. JOHN'S WEST, NFLD.

A projection of vegetable requirements of Canadians indicates that present acreage will have to be expanded to meet consumer needs (story below)

Une projection des besoins des canadiens en végétaux laisse entendre que la superficie présentement en culture devra s'agrandir pour répondre à la demande du consommateur (voir au-dessous)

VEGETABLE FUTURE—Canada will probably have to produce a much greater proportion of her vegetable requirements in the next 10 years than previously.

Certain trends in vegetable production and consumption have developed in Canada and the U.S. during the past 18-20 years which, when projected, can help us predict with accuracy what may occur in the near future.

Canadian consumption of fresh vegetables has increased far faster than our production and, to make up the difference, we have become increasingly dependent on imports. At present 40-50% of our fresh vegetables are obtained from U.S.

Vegetable production and consumption statistics in that country show a surplus being produced there at present. However, vegetable consumption is increasing faster than production there also, and is predicted to overtake production by 1985. Consequently, surplus vegetables on which Canada is dependent could become limited much earlier, making it necessary to find alternate supplies.

To meet Canada's projected requirements, we must produce vegetables in quantities approaching our total requirements. Population projections indicate there will be 24 million Canadians by 1975 and 26.6 million by 1980.

With consumption of vegetables expected to reach 200 pounds per capita per year by 1975, Canada might require the equivalent of an additional 100,000 acres in vegetable production by 1975 and 150,000 acres by 1980.—G.A. KEMP, CDA RESEARCH STATION, LETHBRIDGE, ALTA.

L'AVENIR DE LA PRODUCTION LÉGUMIÈRE—D'ici les dix prochaines années les Canadiens devront probablement produire une proportion beaucoup plus volumineuse de légumes. L'évolution de la production et de la consommation de légumes au Canada et aux États-Unis au cours des dix-huit ou vingt dernières années nous permet de prévoir avec assez de précision ce que l'avenir nous réserve.

De pair avec l'amélioration de l'économie nationale on observe des changements dans les goûts alimentaires des gens. Au Canada, la consommation de légumes frais a grimpé beaucoup plus vite que notre production, ce qui fait que le Canada doit de plus en plus compter sur l'importation pour combler le déficit. A l'heure actuelle, de 40 à 50 p. 100 de nos légumes frais proviennent des États-Unis.

Aux États-Unis, les chiffres indiquent que pour le moment la production dépasse les besoins de la consommation mais là aussi, la consommation de légumes augmente plus vite que la production et on prévoit qu'en 1985 elle l'aura rattrapée. L'excédent actuel de légumes sur lequel compte le Canada pourrait donc se tarir beaucoup plus tôt et il nous faudra trouver de nouveaux fournisseurs.

Si nous voulons faire face aux besoins anticipés du Canada, ajoute M. Kemp, nous devrons faire en sorte que le tonnage de notre production s'en rapproche le plus possible. Les prévisions démographiques établissent à 24 millions la population canadienne en 1975 et à 26.6 millions en 1980.

En se basant sur une consommation de légumes de 200 livres par personne en 1975, le Canada pourrait avoir besoin de l'équivalent de 100,000 acres de plus en culture maraîchère en 1975 et 150,000 acres en 1980.

Il n'y a guère de possibilité d'étendre les superficies légumières de l'Est du Canada. Dans les Prairies, plusieurs régions pourraient convenir à la production des légumes: il existe une zone restreinte non irriguée au Manitoba et une autre région potentielle irriguée en Saskatchewan. Dans le sud de l'Alberta, on dispose de 800,000 acres de terres irriguées dont beaucoup conviennent à la plupart des légumes.

C'est dans cette dernière région que devra se réaliser la principale expansion de la production légumière si le Canada veut arriver à produire les légumes dont il aura besoin à l'avenir—G. A. KEMP, STATION FÉDÉRALE DE RECHERCHES DE LETHBRIDGE, ALTA.

FLORA OF THE QUEEN CHARLOTTE ISLANDS—Five botanists have completed a study of the flora of the Queen Charlotte Islands of British Columbia. The islands are the northernmost remnant of a now almost completely submerged coastal mountain chain, and one of the very few areas of Canada not covered by ice during the glacial period thousands of years ago.

The botanists who gathered data and plant specimens at various intervals during the past few years are: J.A. Calder, CDA Plant Research Institute Ottawa (retired); Dr. R.L. Taylor and G.A. Mulligan, of the Institute; Dr. W.B. Schofield, University of B.C., and Dr. I.M. Brodo, National Museum of Canada. They found the flora much more abundant than expected, counting 594 different kinds of flowering plants. This boosted the previously known total by more than 400. Eleven of the species discovered have ancestries believed to precede the ice age, when similar plants and other vegetation on the mainland were wiped out.

The data obtained is being published by the Plant Research Institute in a 3-volume work entitled Flora of the Queen Charlotte Islands. The first two volumes will be available from the Queen's Printer, Ottawa, in August of this year, and the third may be obtained later.

Intended mainly for professional botanists, the books will also be helpful to naturalists and others interested in the flora of Canada.

molybdenum deficiencies in maritime soils

UMESH C. GUPTA

Molybdenum (Mo) is one of the micro-nutrients that are essential for optimum growth of many crops. The first report of a Mo deficiency in the field was obtained in Australia in 1942. Since that time there have been increasing reports of deficiencies in many areas of the world. In the United States most of the deficiencies reported occur on the soils of the Atlantic and gulf coasts. A study at the CDA Research Station, Charlottetown, has indicated that most of the Maritime soils in Eastern Canada are deficient in Mo.

Often the first and the most obvious symptoms of Mo deficiency are quite similar to those of uncomplicated nitrogen deficiency. This is understandable since Mo is involved with nitrogen in at least two functions in plants. In the case of legumes, Mo stimulates the process of symbiotic nitrogen fixation. More Mo is required for fixing free nitrogen than for utilizing combined nitrogen. Also Mo is an essential element of the enzyme reductase, which reduces nitrate to nitrite in one of the steps of protein synthesis. Without this important step, nitrate accumulates in the tissue and the protein content of the plant is reduced.

Dr. Gupta is a specialist in soil chemistry and fertility at the CDA Research Station, Charlottetown, P.E.I.

In our studies, we found that several factors may affect Mo availability in the soil. Two of the most important are the soil reaction and the amount of aluminum and iron oxides in the soil. In the highly podsolized soils of the Maritime provinces, total Mo is low. In addition, the molybdenum present is unavailable because of low pH which, under natural conditions, is 4.5 to 4.8. Under acidic conditions the $MoO_4^{=}$ ion forms a precipitate with the oxides of Fe and Al and thus becomes unavailable to plants. Apparently, Mo is the only micro-nutrient element that increases in availability with increasing pH of the soil.

The availability of Mo is, to a certain extent, also dependent on the texture of soil. Analysis of Maritime soils with a wide range of texture indicates that coarse-textured soils contain much lower quantities of Mo than the fine-textured ones (Table 1).

It has been found that soils should contain about 0.15 to 0.20 ppm of available Mo for optimum growth of plants. The average available Mo content of New Brunswick, Nova Scotia and Prince Edward Island soils was found to be 0.07, .07 and .024 ppm, respectively. This is less than half the minimum required.

In our experiments conducted in the greenhouse at Charlottetown, we found that an application of 5.0 lb. of Mo per acre increased the yield of cauliflower by 2,000-5,000%, spinach by 400-900%, barley by 20-400%, timothy by 90 to 400%, and alfalfa by 150 to 400%, respectively (Table 2).

The multi-fold increases in the yield of crops, where Mo was added, indicates that these soils are severely deficient in Mo. Response of barley to Mo was shown for the first time and this suggests that other crops may likewise be suffering from a deficiency of Mo in these soils. Barley did not respond to added Mo on one soil that had a very low pH. This probably could be attributed to aluminum toxicity, as Herta barley is very sensitive to aluminum toxicity.

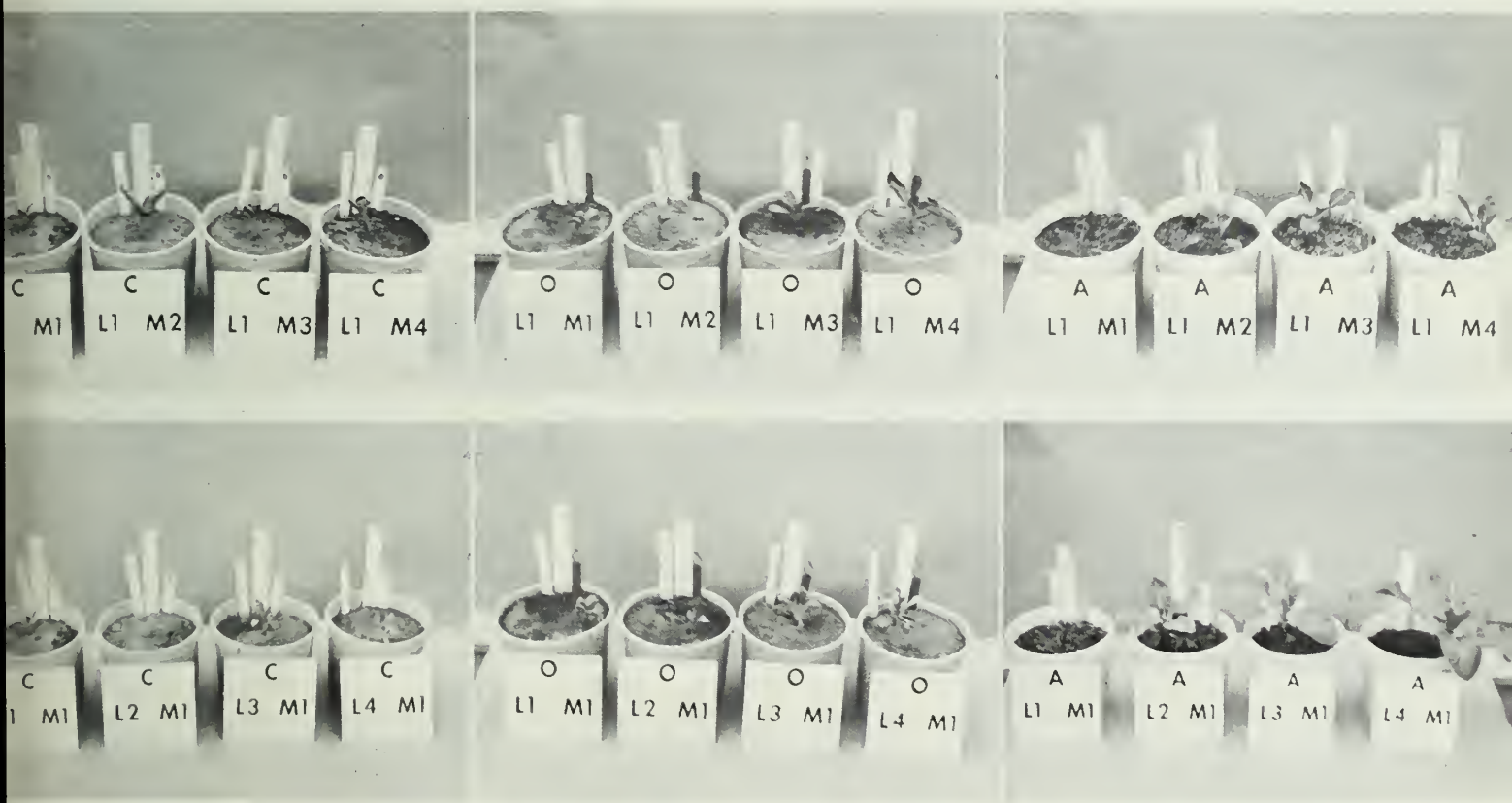
In general, the more acid a soil is, the higher is the level of soil Mo required by the plants. One of our greenhouse experiments at Charlottetown indicated that at pH 5.0 even the highest rate of Mo (20 lb /acre) did not result in increased yield of cauliflower on all the 3 investigated soils (Fig. 1). However, without added Mo, even at a pH of 6.5, the cauliflower crop failed completely on the Culloden and O'Leary soils, while the Acadia soil produced optimum yields at this pH (Fig. 2). It appears that in the Acadia soil there was enough Mo released at higher pH to correct the Mo deficiency. At pH 5.5, an application of only 5.0 lb Mo /acre produced almost maximum yield on all the 3 soils (Fig. 3). ●

TABLE 1. RELATIONSHIP OF TEXTURE WITH Mo CONTENT OF PODZOL SOILS

	Soil Texture	No. of samples	Exchangeable Mo (ppm)
1.	Sandy loam	36	.036
2.	Fine sandy loam	24	.022
3.	Loam to silt loam	14	.040
4.	Sandy clay loam	22	.048
5.	Clay loam	22	.068
6.	Silty clay loam	8	.227

TABLE 2. EFFECT OF Mo TREATMENT ON THE MEAN YIELD (g/pot) GROWN ON SIX SOILS

Crop	Treatment	
	No Mo	5.0 lb. Mo/ Acre
Spinach	0.53	3.22
Herta barley		
(A) Kernels	5.10	8.75
(B) Straw	7.14	9.60
Timothy	3.20	7.00
Alfalfa	1.46	3.26



Top row—Fig. 1; middle row—Fig. 2; bottom photo—Fig. 3

Legends for the figures:
Soils—C = Culloden sandy loam; O = O'Leary sandy clay loam and A = Acadia silty clay loam.
Soil pH—L_1 = 5.0, L_2 = 5.5, L_3 = 6.0 and L_4 = 6.5
Mo applied (lb per acre)—M_1 = 0, M_2 = 5.0, M_3 = 10.0 and M_4 = 20.0

Fig. 1—Oneway disc shredding couchgrass rootstocks. For best results, the discs should be 26 in. in diameter with a 4-in. disc and not spaced closer than 10 in.

Fig. 2—With rotavator, degree of shredding can be regulated by speed of the rotary hoes and of the tractor.

COUCHGRASS-KILLING MACHINES FOR THE WEST

A. C. CARDER

Recent surveys have shown that within the three prairie provinces there are some 4,000,000 acres of cultivated land heavily infested with couchgrass. This represents about 7 per cent of the total crop land. Most of this acreage is in the parkland belt which lies just north of the true prairies. This tract of country, extending from southeast Manitoba to northeast British Columbia, is 1,200 miles long and in places 150 miles wide.

The very tenacity of couchgrass[1], *Agropyron repens*, has set men's minds to work to devise a machine that will rid it from the soil. The objective is eradication rather than control.

Couchgrass-killing machines fall into two categories. First are those implements that kill by shredding the couchgrass rhizomes or underground stems commonly known as rootstocks. In our investigations at the CDA Research Station, Beaverlodge, Alta., we found that this is a fragmentation process and the aim is to segregate the individual regenerative centers on the rootstocks so that all dormant buds are forced to grow for the survival of the segregated parts. Then, when this activity is well underway, we re-tilled to destroy this growth. We discovered that eradication is obtained when either the food reserves to support these activated buds are exhausted, or the supply of buds is depleted. This, the "shredding" method, employs the starvation-by-growth principle. In our study of the machines in the second category, we found that they were designed to drag the couchgrass rootstocks to the surface to be desiccated by sun and wind. This is called the "dragging-out, drying-out" method. Our research revealed that great demands are made on both these methods since the mass of rootstocks may amount to 3 tons per acre, or 80 miles of rootstocks with a regenerative bud about every 2 inches.

Examples of machines that shred are the disc-type and rotary hoe implements. We found that the oneway disc does an excellent job of shredding if it is heavily constructed, properly set, and has sharp cutting edges (Fig. 1). The first three or four workings with this implement must be done on the halflap.

[1]Also known as quackgrass.

Dr. Carder is a specialist in weeds and climatology at the CDA Research Station, Beaverlodge, Alta.

Fig. 3—The couchgrass digger uses the principle of the potato harvester. Soil, couchgrass crowns, rootstocks and roots are lifted and screened, with couchgrass material being deposited on the surface.

Fig. 4—In the furrow-slice shaker, (also an attachment to a gang plow and power-take-off driven), the furrow slice is thrown by rapidly moving curved bars against a grid. This action separates the couchgrass material from the soil.

Fig. 5—The furrow-slice shredder is an attachment to a gang plow. The moldboards are removed and substituted by sets of rapidly turning blades driven by power take-off. The furrow slice is carried over the blades by their anti-clockwise spin and by the foreward movement of the plow. (Note that the blade spindle is missing from the third gang.)

A heavy-duty tandem disc harrow with the leading gang of discs serrated also performs well. Our studies, however, show that the best of all "shredding" machines is the rotavator (Fig. 2). We have closely compared these implements under different soil types and seasons. In moderately wet summers or those favorable to the "shredding" method, we have eradicated couchgrass by use of the rotavator. We have done this also with the oneway disc but not so easily. Weather conditions must be virtually ideal for the oneway disc to provide eradication.

Extreme examples of machines that drag or lift out the couchgrass rootstocks are the potato-digger type (Fig. 3), and the furrow-slice shredder and shaker (Fig. 5 and 4). We found that the rotary cultivator or rotocultivator (Fig. 6) is less drastic than these. Its action is very similar to that of the toolbar cultivator-cableweeder combination, which has the advantage that it is composed of conventional farm implements (Fig. 7). We have thoroughly compared the rotary cultivator against the cultivator-cableweeder combination and found no difference in their killing ability of couchgrass. In summers rather on the dry side complete control was obtained with either of these implements. A rodweeder or oscillating harrow can be used in place of the cableweeder but their action is less effective. A special machine has lately been designed to improve upon the ability of the cableweeder to lift loosened rootstocks to the surface but it has not yet been under test (Fig. 8).

All these machines have their merits and shortcomings. For example, the potato-digger type virtually removes all couchgrass material in one operation but it only performs well in stone-free, light-textured soils. Also, this machine is costly to operate and because it predisposes the soil to erosion is confined to working small acreages. The furrow-slice shaker also pulverizes the soil severely, but it has been known to remove over 90% of the couchgrass material in a single passage. This machine, invented in the mid 1930's, was used against couchgrass on the light soils of southern Manitoba with outstanding success but its use was in part discouraged because of its soil pulverizing action. It was equipped with a device to permit its use in stony land. When war broke out and factories were commandeered to manufacture war

Fig. 6.—Since the rotary cultivator's bands of chisel teeth move in an anti-clockwise direction yet have a forward motion slower than the tractor speed, they dump torn couchgrass rootstocks to the rear.

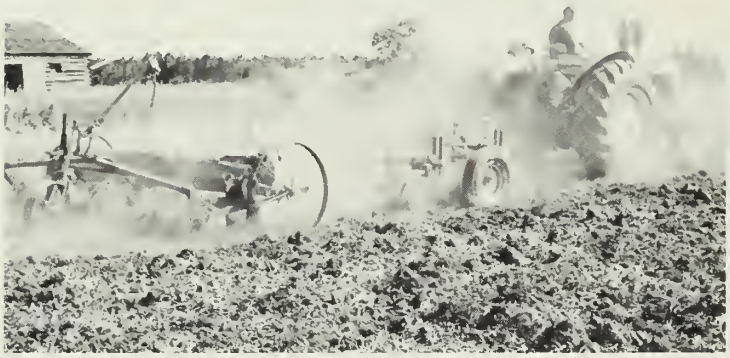


Fig. 7—The action of the toolbar cultivator-cableweeder combination is identical to that of the rotary cultivator. Here a horse-drawn cableweeder weighted with a log is used in place of a more modern unit.

Fig. 8—This machine, with flexible teeth mounted on a rotary drum driven by power take-off, is designed to improve upon the action of the cableweeder.

Fig. 9—An experimental underground sprayer. Below the Noble blade is a spray boom with wide-angle nozzles which effectively spread the herbicide beneath the soil.

materials, the machine was dismantled and unfortunately has never been reassembled and tested under conditions that may prove more suitable to its action. The furrow-slice shredder operates on much the same principle and its strengths and weaknesses are similar. It, too, has never been widely tested.

The machines described immediately above have been designed to do a thorough job with one or at most very few operations. This fact somewhat restricts their versatility. On the other hand, the rotary cultivator will operate satisfactorily in most agricultural soils. Its curved, backward-moving teeth effectively dump the torn rootstocks on the soil's surface, but, as has been pointed out, a combination of conventional farm implements will do this. However, since neither the rotary cultivator or the cultivator-cableweeder combination are thorough in their operation, they require many passages to remove the rootstock mass. They have the advantage, though, that they do not strongly dispose the soil to erosion.

Of the "shredding" machines, the very effective rotavator is not too common a farm implement and is costly to operate. In soils heavily infested with couchgrass, we found that despite its pulverizing action it did not unduly dispose the soil to erosion even after a number of workings. We believe this was because it thoroughly incorporated the plant fiber throughout the soil mass. This machine should not be used on light infestations of couchgrass, or used for more than a single season. As has been indicated, the next best implement for shredding couchgrass rootstocks is the oneway disc.

Not all machines that have been developed for the control or eradication of couchgrass depend solely on a tillage operation to achieve their results. We designed an underground sprayer to place a herbicide where it will do the most good (Fig. 9). For example, the potency of the chemical TCA (trichloroacetic acid) when applied in this way can be increased several times. In our investigations at Beaverlodge, we discovered that the herbicide must be applied after the couchgrass has had prior tillage to activate its rootstock buds so that they are vulnerable to the chemical's action. Indeed, we have experimental evidence which shows that rates of TCA can be reduced to a point where costs are feasible and the residues of the herbicide tolerable to certain following crops such as mustard and rape. ●

This article is a digest of a report entitled "The Structure of the Manufacturing Milk and Cream Industry in Canada" based on the results of a mail-survey conducted by the CDA Economics Branch in 1966. Copies of the detailed report may be obtained from the CDA Information Division, Sir John Carling Building, Ottawa.

THE CANADIAN MANUFACTURING MILK AND CREAM INDUSTRY

W. J. WHITE AND V. A. HEIGHTON

The structure of the Canadian manufacturing milk and cream industry has undergone significant change in recent years. There are many indications that further adjustments are inevitable. This survey was undertaken to obtain quantitative and qualitative measures of these changes and to determine the nature, direction and cause of those adjustments which have taken place and those which are still in process.

The study was designed to provide specific information on various characteristics of the farm business, including physical resources, the nature and relative importance of the dairy enterprise, labor utilization and the use of modern dairy techniques.

A questionnaire was mailed to all dairy farmers registered with the Agricultural Stabilization Board. Since the Board had not registered producers who sold milk to the fluid processors for bottling, at the time of mailing in July 1966, these farmers were not included in the survey. Those producers who had not replied in six weeks were sent an additional questionnaire and a second letter requesting their co-operation. A total of 82,708 farmers out of the 179,242 registered producers returned questionnaires. Of these, 76,112 were sufficiently complete to be used in the analysis. Useful replies were received from 42.5 per cent of the registered farmers.

The answers were analyzed to provide provincial and national frequency distributions for each question. The responses to each question have also been sorted in terms of four characteristics, namely, the number of cows milked, the proportion of total cash receipts received from the sale of milk and cream, the market to which milk and cream were sold, and the age of the farm operator. Appropriate categories were selected for each of these four characteristics so that it was possible to compare the respondents by province.

Dr. White and Mr. Heighton are economists with the CDA Economics Branch in Ottawa, Ont.

THE CONCLUSIONS IN THE REPORT READ:

1. The majority of Canadian manufacturing milk and cream producers operated mixed farms. Most of these farmers received less than half of their income from the sale of milk and cream. Only a small proportion, 17 per cent, of the manufacturing milk and cream producers, received more than three quarters of their income from dairy sales. The production of dairy products was a major enterprise on the farms of only a minority of the manufacturing milk and cream producers.
2. The majority of manufactured milk and cream producers milked a small number of low producing cows. The average number of cows milked was 11.8 per farm. Average sales per farm were 100,187 and 1,492 pounds of milk and cream respectively. An equivalent amount of manufacturing milk and cream could have been produced by a substantially smaller number of farmers if the average number of cows milked per farm had been larger and the production per cow higher.
3. The average size of farms operated by Canadian manufacturing milk and cream producers changed from 236 to 262 acres between 1964 and 1966. This represented an increase of 11 per cent. The average number of cows milked per farm increased only 1.7 per cent during the same period. Although there were major differences between provinces, this suggests that the dairy enterprise is becoming less important in relation to other livestock and crop enterprises on many Canadian dairy farms.
4. Four out of five manufacturing milk and cream producers did not have employment off their farms. Dairy farmers probably were less likely to hold a part-time job, than most other farmers, because of the amount and the nature of labor required to manage a dairy herd. Those who held an off-farm job reported working an average of 106 days per year. There was wide variation from province to province in the percentage of farmers who held off-farm jobs and the average number of days worked.
5. The average age of Canadian manufacturing milk and cream producers was 48 years. The farmers between 31 and 45 years of age had larger farms, milked more cows, and were more likely to sell to a processing plant or a cheese factory than those farmers who were either younger or older. Only 1 dairy farmer in 7 was under 35 years of age while 1 in 3 was 55 years of age or over. Because of this age distribution, a large number of dairy farmers can be expected to leave the industry in the next few years.
6. The level of adoption of modern dairy practices was low, particularly for those farmers in Saskatchewan, Manitoba and Nova Scotia. Nationally, less than one third of all the farmers reported using a milking machine and either a can cooler or a bulk tank. A minority of manufacturing milk and cream producers were utilizing modern labor saving machinery and up-to-date management practices such as production recording and artificial insemination. ●

INOCULATION DI EN SOL ACIDE

M. L. DESSUREAUX

LA LUZERNE EN SOL ACIDE

Les sols acides ne sont pas propices à la culture de la luzerne. Lorsque le degré d'acidité d'un sol, (son pH) est aux environs de 4.7, il est pratiquement impossible d'y cultiver cette plante fourragère. Le plant ne pousse pas; les bactéries (Rhizobium) ne se multiplient pas normalement. Or, elles sont indispensables pour la production de l'azote nécessaire à la croissance de la plante.

Les Rhizobia produisent de l'azote avec de légers résidus acides et cela, au détriment de la luzerne lorsqu'elle croît dans un sol déjà acide.

Dans un de ses articles, D. O. Norris d'Australie[1] a démontré qu'il existe certaines lignées rares de Rhizobium capables de produire des résidus alcalins plutôt qu'acides. La présence de ces résidus alcalins devrait dans une certaine mesure corriger le degré d'acidité dans l'environnement des racines et par conséquent favoriser le développement de la luzerne dans un sol acide.

LES RECHERCHES AU CANADA

Une bonne partie des sols de la province de Québec et ceux du Nord de l'Ontario sont acides et rendent difficile l'établissement de la luzerne.

La section des plantes fourragères de la Direction de la recherche du ministère de l'Agriculture du Canada à Ottawa a tenté de mettre en application la découverte du Dr Norris, en étudiant la symbiose des lignées de Rhizobium sélectionnées, avec des lignées de luzernes sélectionnées à la station de recherches de La Pocatière pour leur tolérance au sol acide.

Pour nos travaux nous avons utilisé du sol acide prélevé dans une section non chaulée de la ferme expérimentale de La Pocatière et transporté à la ferme expérimentale centrale d'Ottawa où nous avons conduit les expériences. Notre but était de démontrer si la symbiose avec des souches actives de Rhizobium alcaligène améliorerait la croissance de la luzerne en sol très acide.

LUZERNE ET SOLS ACIDES FERONT-ILS BON MÉNAGE?

Le sol utilisé avait un pH de 4.7. Nous avons étudié le comportement de deux variétés de luzerne: la Vernal et la Syn AT4, nouvelle lignée expérimentale synthétique, issue de la Vernal et sélectionnée pour sa tolérance à l'acidité du sol.

Les essais ont été effectués avec ou sans inoculation de 3 souches australiennes de Rhizobium reconnues pour leur tolérance à un degré d'acidité assez élevé. Ces souches de Rhizobium CB112, CB227 et CB1170, en provenance du laboratoire de D. O. Norris nous ont été préparées et fournies par N. J. Hahn de l'institut de recherches sur la biologie cellulaire d'Ottawa. Elles sont toutes trois réputées pour leur activité et leur propriété alcaligène.

Le sol a été disposé dans 24 pots de polyéthylène de 4 pouces carrés; 12 pour la Vernal et 12 pour la

[1]Norris, D. O.—"Legumes and the Rhizobium Symbiosis" —Empire journal of experimental Agriculture—vol. 24, page 247-270; 1956, and "Acid production by Rhizobium—a unifying concept". Plant and soil, International journal of plant nutrition, plant chemistry, soil microbiology and soil-borne plant disease, vol. XXII, No. 2, 1965. D. O. Norris du C.S.I.R.O., Division of tropical pastures, Cunningham Laboratory, Brisbane, Australia.

L. Dessureaux est un spécialiste de la Section des plantes fourragères de la Station de recherches d'Ottawa, Ferme expérimentale centrale. Cet article a été écrit par Jean Baroux de la Division de l'information, en collaboration avec L. Dessureaux.

Ces nodules démontrent l'efficacité de la symbiose

LA LUZERNE

Syn AT4. Les pots ont été séparés en 4 groupes dont un groupe témoin non traité et 3 groupes traités chacun avec une des 3 lignées d'inoculum.

Le 20 février, date du semis, nous avons introduit dans les 3 groupes de pots à traiter 250 ml d'inoculum chacun, avant d'enterrer 16 graines de luzerne dans chaque pot. Le 4e groupe de pots servant de parcelle témoin n'a pas reçu d'inoculum mais nous y avons tout de même versé le même volume de solution liquide mais sans bactéries, avant d'y faire un semis identique aux trois autres groupes de pots. Le 1er mars nous avons réitéré l'inoculation à raison de 26 ml par pot en suivant le même processus pour les différents groupes de pots.

OUI! AVEC L'INOCULATION DE CERTAINS RHIZOBIA

LA GERMINATION

D'après le tableau 1, on constate que: la germination a été quelque peu irrégulière; le nombre de graines germées a été plus élevé pour la Syn AT4 que pour la Vernal; la germination de la Vernal inoculée au CB227 a été particulièrement pauvre; rien ne prouve cependant que l'inoculation de Rhizobium ait une influence marquante sur la germination.

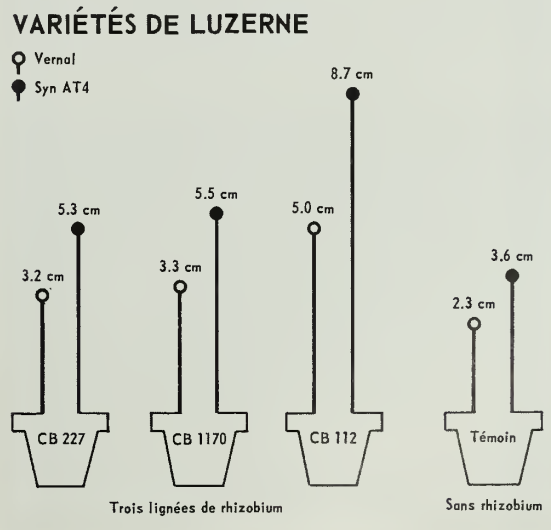
TABLEAU 1—NOMBRE DE GRAINES GERMÉES POUR DEUX VARIÉTÉS DE LUZERNE TRAITÉES AVEC 3 SOUCHES DIFFÉRENTES DE RHIZOBIUM.

Lignées de Rhizobium	Vernal	Syn AT4
Témoin	6.3	8.3
CB 112	5.7	6.0
CB 227	3.7	10.0
CB 1170	7.0	11.7
Moyenne	5.7	9.0

LA HAUTEUR DES PLANTULES

La hauteur de chaque plantule a été mesurée le 50e jour du semis (Figure 1). Les deux variétés de luzerne traitées au Rhizobium se sont plus développées que le témoin. La souche de Rhizobium la plus active semble être le CB112. En confirmation des résultats de travaux de sélection de luzerne, notons que la variété Syn AT4 a atteint une hauteur supérieure à celle de la Vernal.

FIGURE 1—HAUTEUR DES PLANTULES DE LUZERNE EN SOL TRÈS ACIDE, TRAITÉES AVEC LES 3 DIFFÉRENTES SOUCHES DE RHIZOBIUM



(*A suivre page 26*)

LA VARIANCE INTRA-POTS

En mesurant la hauteur des plantules nous avons constaté une grande variation entre différentes plantes et particulièrement dans certains pots. Nous avons donc décidé d'analyser ces variances intra-pots afin de déterminer l'existence possible de certaines tendances. Les résultats de cette analyse sont présentés au tableau 2.

La variance intra-pots s'est avérée très faible dans les pots témoins mais très élevée dans les pots traités avec la souche CB112. Les souches alcaligènes de Rhizobium ont donc accru la variance intra-pots. Cette tendance s'est manifestée avec plus d'évidence pour la variété améliorée Syn AT4.

TABLEAU 2—VARIANCE INTRA-POTS DE DEUX VARIÉTÉS DE LUZERNE CROISSANT EN SOL ACIDE ET TRAITÉES AVEC 3 DIFFÉRENTES SOUCHES DE RHIZOBIUM.

Lignées de Rhizobium	Variétés de luzerne		Variance des totaux
	Vernal	Syn AT4	
Témoin.....	1.61	1.80	1.72
CB 112.....	17.81	31.22	24.73
CB 227.....	4.36	11.68	9.95
CB 1170.....	9.65	9.64	9.64
Total.....	8.80	11.75	10.68

POIDS DE LA LUZERNE DESSÉCHÉE

Nous avons pesé les racines et parties aériennes des plantules desséchées le 7e jour de semis. Le tableau 3 indique ces poids secs. La production de matière sèche a doublé dans les plantes traitées avec les souches CB227 et CB1170; elle a quadruplé dans les plantes traitées avec la souche CB112. La variété Syn AT4 a produit trois fois plus que la Vernal. Nous avons noté que les traitements avec les souches CB227 et CB1170 n'ont pas amélioré le rendement de la Vernal mais ont par contre nettement accru celui de la Syn AT4.

TABLEAU 3—RENDEMENT DE DEUX VARIÉTÉS DE LUZERNE EN SOL ACIDE, EN CROISSANCE SYMBIOTIQUE AVEC DIFFÉRENTES SOUCHES DE RHIZOBIUM.

Lignées de Rhizobium	Variétés de luzerne		Moyenne
	Vernal	Syn AT4	
	gm	gm	gm
Témoin.....	.06	.14	.10
CB 227.....	.06	.34	.20
CB 1170.....	.09	.36	.22
CB 112.....	.27	.55	.41
Moyenne.....	.12	.35	—

COMMENTAIRES SUR LES ESSAIS

Cette simple expérience démontre qu'on peut améliorer la croissance de la luzerne par l'inoculation de souches actives de Rhizobium alcaligène dans les sols très acides. Les différences observées dans l'activité des souches bactériennes, devraient encourager les recherches pour d'autres souches actives de Rhizobium alcaligène. Pour obtenir une croissance satisfaisante de la luzerne en sol acide, il faut non seulement des plants de luzernes tolérants à l'acidité mais aussi des souches de Rhizobium adaptées à ce milieu et dotées d'une forte activité symbiotique. Les résultats de la présente étude devraient stimuler la recherche de souches alcaligènes actives de Rhizobium dans les sols acides de l'Est du Canada.

Nos essais ont prouvé que la souche la plus active de Rhizobium engendrait la plus grande variabilité dans les plantes de luzerne. Ceci peut s'expliquer par le fait qu'aux différences phénotypiques des bactéries sur le plan de la nutrition, s'ajoutent celles de la plante-hôte sur le plan de la symbiose. En d'autres termes, il y a une interaction entre l'hôte et le Rhizobium, comme l'indique la variance intra-pots. En conséquence, la recherche de la lignée de luzerne tolérante à l'acidité sera grandement facilitée si on cultive les lignées dans un sol inoculé de la souche de Rhizobium la plus active.

Les meilleurs résultats obtenus avec la variété Syn AT4 par rapport à la Vernal, s'expliquent par le fait que la Syn AT4 a été sélectionnée antérieurement pour sa tolérance à l'acidité du sol. En effectuant cette sélection pour la tolérance, il est fort possible que nous ayons involontairement augmenté la proportion de génotypes de grande capacité symbiotique. Cela signifierait que dans la flore bactérienne des sols acides il devrait être possible d'isoler des souches de valeur supérieure.

En conclusion, nous pouvons dire que les trois souches australiennes de Rhizobium alcaligène, et en particulier la CB112, ont été efficaces dans le traitement de la luzerne cultivée en sol très acide. Il reste à déterminer leur degré de supériorité par rapport aux cultures commerciales utilisées actuellement. Il faudrait aussi chercher s'il existe des souches alcaligènes semblables dans nos sols acides et découvrir leur degré d'activité symbiotique.

Si notre programme de sélection de la luzerne pour la tolérance à l'acidité des sols doit être poursuivi, il est indispensable que nous menions de pair des recherches de cette tolérance chez le Rhizobium, soit par sélection à même la flore naturelle du sol soit par des méthodes de reproduction plus complexe. ●

THE USE OF OIL AS A PESTICIDE

K. WILLIAMS

Petroleum oils have been used for many years for the control of orchard pests in the fruit-growing areas of the world. In the Okanagan Valley of British Columbia, a heavy dormant oil has been recommended for the control of some pests for several years. Recently, this dormant oil has also been recommended for use on apple trees up to the tight cluster bud stage.

Today the use of oil as a pesticide in orchards is being re-emphasized in pest control. Experiments at the CDA Research Station, Summerland, B.C. show that a supreme-type oil and some 70-second superior type oils can be used when trees are in foliage.

The spray oils produced now are quite different from those produced in the past. They are more highly refined, less injurious, more effective and have more rigid specifications. It should be emphasized, however, that even oils of similar specifications may vary in their effectiveness. Even the type and amount of emulsifier used in their formulation can reduce the effectiveness against certain pests and may also have an effect on their safety for use on foliage and fruit.

Plant tolerance is a limiting factor in the use of spray oils. Research workers have found that the aromatic or unsaturated constituents of an oil were the fractions most responsible for oil injury. The supreme-type or superior-type oils now being recommended for post-bloom sprays have most of the aromatic or unsaturated constituents removed in the refining process. The heavy dormant oils are not as highly refined and they contain more of the undesirable constituents. Consequently, the heavy oils can only be used pre-bloom whereas the supreme-type or superior-type can be used throughout the year.

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Although the lighter summer oils are highly refined and meet rigid specifications, there is always a possibility of injury. But when properly applied, alone, to healthy trees at the recommended rate, they cause little or no injury. Yet if the trees are oversprayed or are in poor vigor, the possibility of injury increases. Spray oils are also more likely to injure foliage if the spray dries slowly or if extremely hot weather follows the oil application. Some varieties of pear and apple trees are more susceptible to injury than others. Oil sprays can be used on the Bartlett variety of pear tree but not on Anjou.

In our investigations at Summerland, we discovered one unusual type of injury on Red Delicious apple trees sprayed with supreme-type or superior-type oil in the delayed dormant. The injury consists of enlarged corky lenticels on the bark. A similar type of injury also occurs on pear trees. But, unlike Red Delicious apple trees, the injury occurs in delayed dormant and the post-bloom period. The degree of injury is correlated to the number of sprays applied. The injury does not appear to have any adverse effect on the vigor of the tree. The lenticels on the fruit of Bartlett pear trees are a darker green when oils are applied post-bloom but this disappears during the ripening period.

Probably the greatest hazard in the use of oil sprays is that many spray chemicals applied to orchard trees are incompatible with oil. If these chemicals are tank-mixed with oil, severe injury to leaves or fruit can occur. An additional problem is that injury can also occur if certain of these spray chemicals are applied too soon before or after an oil spray. Anyone contemplating the use of summer oils should be aware that there is a certain amount of risk involved. The risk can be greatly reduced by careful application, reading the labels on spray chemicals and consulting the compatibility chart in the local spray recommendations. ●

FOR SOUTHWESTERN ONTARIO

BREEDING BLIGHT-RESISTANT

R. E. C. LAYNE

Fig. 1—Screening for fire-blight resistance in the greenhouse. (Note diseased plants in foreground and humidity chamber in background).

Fig. 2—Blight resistant, 4-year-old seedlings in the orchard. (Note weed-free strips and cover crop.)

There is only one major problem facing the pear industry of southwestern Ontario. It is the disease called fire blight, caused by a bacterium named *Erwinia amylovora.* A reliable, inexpensive means of controlling fire blight could result in a major expansion of the pear industry for several good reasons:

- *The demand for Ontario grown pears for fresh use and for processing is good, the price is good and the supply is inadequate.*
- *The climate and soils are suitable with an abundance of lower cost, heavier type soils, suitable for pears but unsuitable for other tree fruits.*
- *Fewer labor costs are involved in pruning, spraying and harvesting pears than with any of the other tree fruits.*
- *The net returns per acre from pears are higher than for most other tree fruits.*

But unfortunately, the current recommendations for fire blight control, while helpful, are inadequate and expensive. In addition, most of the commercially important varieties are very susceptible. Resistant varieties provide the best, safest, and in the long run the least expensive means of control. Such varieties do not exist at present, but an intensive research effort is being made at the CDA Research Station at Harrow to develop suitable, blight resistant varieties for the basket and processing trades.

We are cross breeding most of the known sources of blight resistance to the best commercial varieties that are broadly adapted and have high quality fruit. We expect, in the offspring, to obtain new combinations that have the disease resistance of the resistant

Dr. Layne is a fruit breeding specialist at the CDA Research Station, Harrow, Ont.

parents and the high quality fruit of the susceptible parents. Some of the sources of resistance came originally from Japan, China and Manchuria. Others have come from Europe, after further breeding and selection in the United States.

Progress in the development of resistant varieties has been greatly aided by the development of an efficient, reliable, method of screening thousands of seedlings for resistance to the disease under controlled conditions. This method has made it possible for us to screen up to 10,000 seedlings a year with infection usually in the order of 90 to 100%.

Seeds are planted in fiber pots in an inexpensive, plastic greenhouse in January. In July, when the plants are 2 to 3 feet tall, they are inoculated with a potent strain of the fire blight bacterium. Immediately after inoculation the plants are placed in a large chamber for 3 days where the humidity is held at 95 to 100% at temperatures between 75 and 85° F. These conditions favor good infection and disease development. The plants are removed from the chamber and the disease is allowed to run its course in the greenhouse. A view of the infected pear seedlings and the humidity chamber in the background is shown in Fig. 1.

In September all infected seedlings are grouped into four classes based on the percent of the shoot blighted. Those that blight less than 25% are placed in the most resistant class. Those that have 25 to 50% of their total length blighted are placed in the moderately resistant class. Seedlings that have 50 to 75% blight are considered moderately susceptible and those that have 75 to 100% blight are highly susceptible. Both susceptible classes are discarded in the greenhouse and only the first two classes are planted in the orchard in early October.

Resistant seedlings are planted in the orchard in semi-hedge rows to conserve space. Here they are grown to fruiting and evaluated for productivity and quality. The trees are spaced 5 feet apart in the row with 15 feet between rows. Chemical weed killers are used to control weeds in the row and a cover crop of oats is planted in June, between the rows, to conserve moisture, control weeds, and prevent erosion. The cover crop is mowed regularly and the stubble is left to overwinter. A small part of the seedling orchard with some of the 4-year-old blight-resistant seedlings is shown in Fig. 2.

One of the most exciting dividends that has come from this research is the discovery that several of the European sources of resistance, such as Magness, Maxine and Farmingdale are exceptionally efficient transmitters of fire blight resistance. These varieties already have fruit qualities which are at or very near the level required for commercial acceptance. These sources of resistance have frequently exceeded the capacity of the Asiatic sources in ability to transmit resistance. Since the Asiatic sources usually have small fruit with gritty flesh and generally unacceptable quality, several generations of cross breeding would be required to improve fruit quality.

The prospect of obtaining high quality, blight-resistant pears, perhaps in a single generation, looks very good for the European sources of resistance. For this reason, we are now placing the greatest emphasis on using these sources of resistance. But the Asiatic sources will also be used since they furnish other useful characters such as winter-hardiness and *Fabrea* leaf spot resistance. However, they will not be used as extensively. We are very hopeful that suitable, blight-resistant varieties will be available to growers for trial plantings before 1975. •

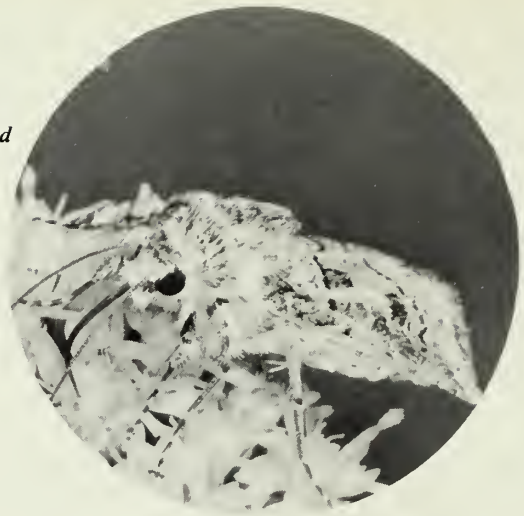

Fig. 1—Pale western cutworm moth feeding on goldenrod

cutworms OF THE PRAIRIES

L. A. JACOBSON

Over the past 50 years, cutworms have been major crop pests in western Canada. Only infrequently during this period have infestations and damage not been reported from some area of the prairie region.

Cutworms are smooth, hairless, larvae of noctuid moths and are so named because of their habit of cutting plants at, or just below, the surface of the soil. Of the several hundred species of moths commonly seen during the summer and fall flying around lights and illuminated windows, about twenty species represent cutworms that have caused damage to field and garden crops. Three of these—because of their frequent occurrence and the millions of dollars worth of cereal crop losses they have caused—are of major importance, notably the pale western cutworm, *Agrotis orthogonia* Morrison; the red-backed cutworm, *Euxoa ochrogaster* (Guenée); and the army cutworm, *Chorizagrotis auxiliaris* (Grote). Several others are important pests of oilseed crops, and still others, important pests of home and garden crops. In our research at CDA Research Station, Lethbridge, Alta., we have been concerned mainly with the three cutworms of cereal crops.

The pale western cutworm is a native of the open, shortgrass prairie and its normal occurrence is limited to the semi-arid areas of Alberta and Saskatchewan. It also occurs in similar habitats of the open plains area of the United States, south to New Mexico and east to Kansas and Nebraska.

The author specializes in cutworm research at the CDA Research Station, Lethbridge, Alta.

The red-backed cutworm is native to a more humid habitat and in Western Canada it is the most common cutworm in the open parkland areas. Its range of occurrence is wider than that of the pale western cutworm. It is found in eastern Canada, southward along the mountain system of the western United States, and is relatively common in Alaska.

Occasionally, depending upon climatic variations from year to year, the occurrence of these two cutworms may shift geographically, or even in some cases overlap.

The army cutworm is less widely distributed. It occurs nearer the mountains. In Alberta it is found normally in areas south of Calgary while in Saskatchewan it has caused damage only in the extreme southwest part of the province.

Fig. 2—Head on view of pale western cutworm larva

LIFE HISTORY

The three species differ slightly in their life history and in distribution. The differences in development and the period of maximum damage are shown in Fig. 3.

Both the red-backed and the pale western cutworm overwinter as eggs, hatch about the same time, and complete their feeding in late June. Full-grown larvae are about 1½-inches long. Shortly after reaching larvae stage they become pupae in the soil and remain there for a month or more. Red-backed cutworm moths emerge in late July and begin laying eggs about 10 days later. Flight period and oviposition continues until early September. Moths of the pale western cutworm are present from August 15 for about a month. The moths can lay eggs within a few days of emerging.

Eggs of the two species have different characteristics. Both undergo a diapause, a period of suspended development that prevents hatching until spring when food will be available. The eggs of the red-backed cutworm, which are laid earlier and incubate more quickly, have a strong diapause requiring several months of cold temperatures before hatching. Eggs of the pale western cutworm have a weaker diapause. If the weather is unusually warm during the autumn months, it is sufficient to prevent hatching. Only a few instances of hatching in autumn have been recorded.

Army cutworms spend the winter as partly grown larvae, resume feeding in the spring and usually complete their development before the first of June. After a short resting period as pupae in the soil, the moths emerge in late June, but do not lay eggs until September and October. There is some controversy as to where they spend the interval. In Nebraska, there is some evidence that they migrate some distance to the mountains to escape the warm summer and return in the autumn to lay eggs. In western Canada, no direct evidence of this has been found although the occurrence of infestations adjacent to mountains and high hills lends some support to this theory. Since the nights in these areas are relatively cool, it is possible that the moths escape high temperatures during the day by hiding in buildings, crevices in the ground, or under rocks.

All cutworm moths require food and moisture to sustain them for oviposition. The most common source is the nectar of native flowers. Goldenrod, wild sunflowers, and to a lesser extent other flowers are the usual feeding sites during early evening and during the night.

Slight differences occur in feeding habits and food preferences of the three species. The pale western cutworm feeds mainly underground and exhibits a preference for wheat. The red-backed and the army cutworm feed mostly above the ground, although when not feeding they are found under the soil. They feed on a greater variety of plants including coarse grains, flax, rape, mustard, and garden crops.

When cutworms are small, they cannot inflict serious damage. They can be recognized by small feeding holes in the leaves of plants. As the cutworms grow larger, they can cut off the entire plant as they eat more food. Hence, a full-grown larva will consume many more plants in a day than a half-grown one. Similarly, as a wheat plant becomes larger it becomes more resistant to cutworm feeding. This is one reason why winter wheat can withstand higher populations of the pale western or army cutworm than spring wheat at a similar period in the spring. We have found in greenhouse and plot studies that the final damage to plants in the two-leaf stage with one half-grown larva per square foot was almost identical to that which occurred when five larvae per square foot were feeding on wheat in the early tillering stage.

(continued on page 32)

Fig. 3—Life history of three prairie cutworms

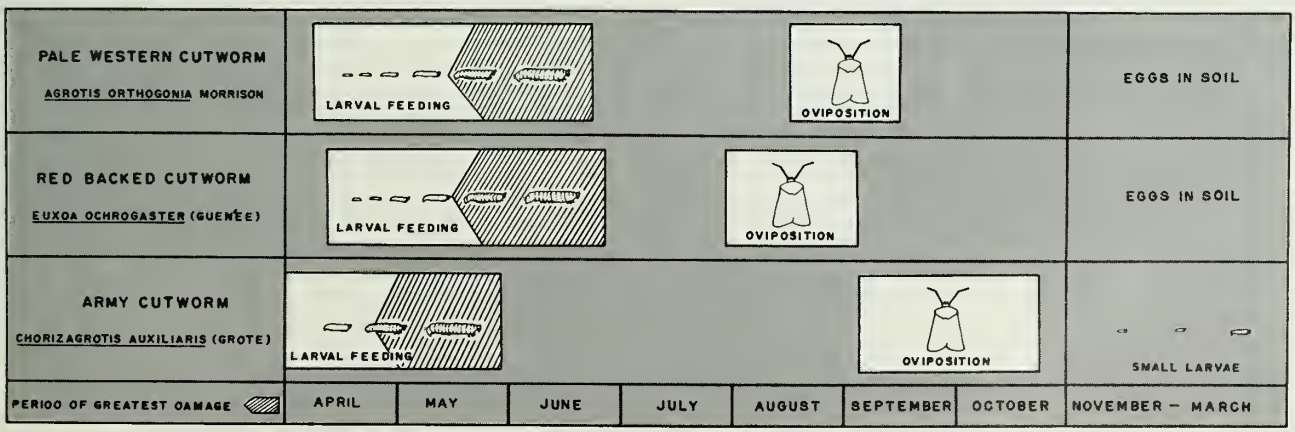

Fig. 4—Field of spring wheat destroyed by pale western cutworm

CULTURAL CONTROL

For many years, the most important method of controlling the pale western cutworm was the prevention of infestations by not cultivating summer fallow when the moths were laying eggs. When the soil becomes crusted, moths cannot penetrate it with their ovipositions to lay eggs. However, the red-backed cutworm prefers a site where weed growth is present. Hence, weeds should be destroyed in areas where it is a recurring pest to discourage egg laying. This cultural method of preventing infestations on summer fallow is an effective and economical method of reducing damage but as the acreage of grain seeded on stubble increases other methods of control must be considered.

CHEMICAL CONTROL

For many years, it was considered unlikely that soil-infesting cutworms could be controlled with insecticides. In the early 1950's, we found that aldrin, dieldrin, and later endrin, sprayed on the soil surface were effective in protecting crops from attack by cutworms. A distinct advantage of the use of insecticides was that damaged fields, sprayed with an insecticide, could be reseeded immediately. Previously, such fields could not be reseeded until the larvae had ceased feeding, usually about June 20. This date was often too late to ensure a crop of wheat and often it was necessary to leave the field fallow for another year or seed it to a less remunerative crop.

More recently it was found that persistent residues from cutworm applications of organochlorine insecticides, including aldrin, dieldrin, and endrin, could be detected in animal and human food. Less persistent compounds—some organophosphates—were tested in 1965 against the pale western cutworm and several were found extremely effective. We plan further field tests against the red-backed and army cutworm which should produce recommendations of insecticides and rates for control of three cutworm species.

BIOLOGICAL CONTROL

In addition to research on effective and safer insecticides, investigations are proceeding at the Lethbridge Research Station on biological studies and nutrition that will lead to other methods of reducing populations of cutworms. Intensive research is being conducted on adults of the three species to learn more about conditions that influence mating, flight behaviour, and oviposition. The objective is to devise methods of sterilizing male moths by radiation or chemicals after attracting them with sex attractants. These methods have been exploited successfully with other insect species. Almost every year other cutworm species occur on various crops and are investigated for details of life history, feeding habits, and appraised as potential pests. ●

RECOGNITION OF PRAIRIE CUTWORMS

	PALE WESTERN	RED-BACKED	ARMY
Geographic occurrence	Open plains	Park land	Southern areas
General color	Light grey	Reddish	Dark olive green
Distinguishing marking	Straw yellow head with blackish X or V	Brick red band along body	Rows of spots or dull yellow band along top of body
Period of damage	Mid-May to late June	Mid-May to late June	April and May

PUBLICATIONS

Copies of these, and a list of other publications may be obtained free of charge (unless otherwise stated) from: Information Division, Canada Department of Agriculture, Ottawa.

On peut obtenir gratuitement (à moins d'avis contraire) des exemplaires de ces publications ainsi qu'une liste d'autres publications à: la Division de l'information, ministère de l'Agriculture du Canada, Ottawa.

1288 GROWING CANADA'S FLORAL EMBLEMS. Colored photographs of all of Canada's provincial floral emblems together with suggestions about how to grow them in your own garden. Available from the Queen's Printer, Ottawa 50¢.

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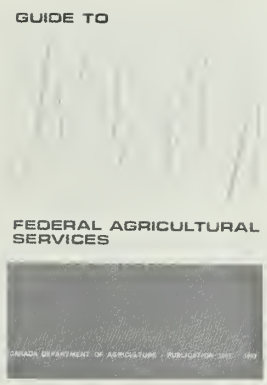

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